

THE COLOUR PRINTING OF CARPET YARNS

THE
COLOUR PRINTING
OF
CARPET YARNS

A USEFUL MANUAL
FOR
COLOUR-CHEMISTS AND TEXTILE PRINTERS

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"EXAMINATION OF COLOURS AND THEIR APPEARANCES UNDER
ARTIFICIAL ILLUMINATION," ETC.

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TO
MY FATHER,
WHOSE LIFELONG EXPERIENCE
IN
TEXTILE COLOUR PRINTING
HAS EVER PROVED
A SOURCE OF KNOWLEDGE AND HELP
TO THE AUTHOR,
THIS LITTLE WORK
IS
affectionately dedicated.

PREFACE.

NOTWITHSTANDING the many excellent technical books which have appeared on the Dyeing and Printing of Textile Fabrics, there still remains the need for a practical little treatise on the colour printing of carpet yarns. The present writer contributed a series of articles on the subject to the *Dyer and Calico Printer*, the reception of which proved so encouraging as to warrant his publishing them in this much revised and enlarged form.

It is to be hoped that this little manual may supply a want in our Textile Literature.

D. P.

LEA BANK,
ROSSLYN, MIDDLESEX,
January, 1900.

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THE COLOUR PRINTING OF CARPET YARNS.

CHAPTER I.

THE STRUCTURE OF THE WOOL FIBRE—PHYSICAL AND CHEMICAL PROPERTIES—WOOL GREASE—ACTION OF HEAT—ALKALIES—ACIDS ON WOOL—AFFINITY FOR COLOURING MATTERS—WOOLLENS AND WORSTEDS.

IN order to obtain the best results in our textile manufactures, it is necessary that those engaged in the work should have a clear and intelligent idea of the nature of the raw materials which pass through their hands. No fibre requires more careful attention in this respect than wool. Its structural and chemical differences from the vegetable fibres render it more difficult of successful treatment. It must always be remembered that the best possible results can only be obtained where there is a thorough technical knowledge of the various processes through which the fibre passes. Before treating of the scouring and bleaching of the wool, therefore, it may be of advantage to state briefly some of the physical and chemical characteristics of the wool fibre. When viewed under the microscope, a typical wool fibre represents an appearance similar to Fig. 1.

WOOL FIBRE.

It will be seen that the fibre is covered externally with thin plates, irregular in shape, and arranged similar to the scales of the fish or tiles on a roof. This is a very character-

istic appearance of wool, and one which makes it readily recognised among the other textile fibres. This rough surface of the wool plays a most important part in causing the "felting" or "milling" of woollen material. When subjected to friction in the scouring process, and especially if a slight excess of alkali be present, the scales of the fibres become matted and interlocked with each other, and cannot

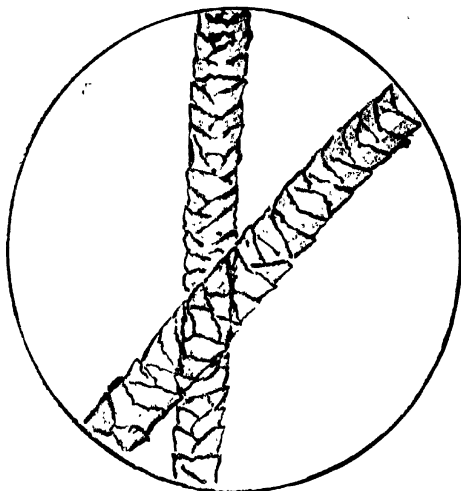


FIG. 1. Typical wool fibre, as seen under microscope (showing epithelial scales).

readily be separated. This matting or "felting" property is taken advantage of in the process of "milling" for the manufacture of various woollen articles, such as flannels, felt hats, tweeds, etc.

This felting property, however, is a serious drawback in the scouring and dyeing of yarn, and every care must be taken to avoid it. Long boiling, over-steaming (see Fig.

13), rough treatment, and too high a temperature in the scouring operations are all apt to produce felting.

Under the external covering of scales lies the cortical substance of the wool fibre itself, which forms, in most cases, the whole inside portion of the fibre. This consists of bundles of long narrow cells of a horny nature, which possess a certain affinity for colouring matters. When the wool fibre is disintegrated, either by the action of sulphuric acid or by excessive heating (see illustration under Steaming, Fig. 15, B), these cells become separated and give to it a fibrous appearance when viewed under the microscope. In dyeing or colour printing on wool it is necessary to have the presence of an acid to fix the colours in the fibre. This is ascribed to the action of the acid or mordant in opening these external epithelial scales, and allowing the dye solution to enter into the interior of the fibre.

Physical Qualities.—What are known as “kemps” are dead or lustreless fibres, more resembling hair, which do not possess the usual appearance of wool under the microscope. The scales are generally invisible, and the fibre is so dense as to be almost opaque. Such fibres have no attraction for colouring matters, and it will be noticed that dyed yarns, having a quantity of kemp, look dry and poor in colour.

Wools differ greatly in their affinity for colouring matters. Those taken from sheep that have had disease, or those cut from the dead animal, never dye so bright and rich colours as the wool cut from the healthy living animal. Chevreul, in his researches on this subject, has shown that three such specimens of wool gave different colours when dyed in the same dye bath. From what has been stated it will be seen that the wool fibre is much more sensitive and easier damaged than the vegetable fibres, such as cotton or linen, and we cannot wonder that so delicately constructed a fibre, only

$\frac{30}{1000}$ of an inch in diameter, and having 6000 scales per inch, is so readily injured in the various processes of manufacture.

Physical Properties.—Three physical properties of wool are of interest to the textile manufacturer. These are: (1) its power of absorbing moisture, or its *hygroscopicity*; (2) *lustre*; (3) *elasticity*.

(1) When ordinary raw wool is dried at 212° Fahr. (100° C.) it loses on an average 18.25 per cent. of moisture; but when exposed to temperatures above this the fibre is injured. When lying exposed to the air in fine dry weather it is found to contain something like 12 per cent. moisture, while in a damp foggy atmosphere it has been found to absorb 30 per cent. of its weight of water. This hygroscopic nature of *unwashed wool* renders it necessary to fix a certain official standard of moisture present in the wool, and various wool conditioning establishments, conducted on similar principles to silk conditioning, have been instituted in the great wool centres on the continent and also at Bradford. The legal amount of moisture allowed is 18.25 per cent.

(2) The *lustre* of wool is another important feature to be considered. This varies considerably with the variety of wools. The lustre of the fibre depends principally upon the arrangement and transparency of its external scales. If these lie close and flat to the surface of the fibre, it will give a fibre of good lustre. If, on the other hand, the scales are rough and outstanding, as in our illustration Fig. 1, a non-lustre wool is produced. Hard glossy wools, with a high lustre, do not as a rule dye so readily as those possessed of little or no lustre. This might be presupposed from the fact we have already stated, that, in dyeing, the scales are opened by the gentle action of an acid, and the colouring matter is thereby admitted into the interior of the fibre.

(3) The *elasticity* of the wool fibre is readily determined by gradually stretching out a selected fibre until it breaks, and

then noting how the broken parts rebound to their former position. A fibre of little elasticity remains in much the same position, similar to a thread of cotton, while a good elastic fibre shrinks and twists up when over-stretched.

The quality of a wool is determined by paying careful attention to its various physical properties, elasticity, lustre, softness of feel, length of fibre or staple, its waviness and strength.

Chemical Composition—In its chemical constitution the wool fibre differs from any of the vegetable fibres, in containing *nitrogen* and *sulphur*. The pure fibre, when cleansed from all foreign matters, consists of an organic substance called *keratine* (or the *horn* substance), similar in chemical constitution to horn, feathers, whalebone, etc. As the composition of this substance varies considerably—especially in the percentage of sulphur—it cannot be looked upon as a definite chemical compound, to which a formula could be assigned. The following analysis may be taken as representing the average composition of the wool fibre proper:—

Carbon	69.25 per cent.
Hydrogen	7.57 „
Oxygen	23.66 „
Nitrogen	15.86 „
Sulphur	3.66 „
100.	

When the fibre is burned it leaves an ash amounting to about $\frac{1}{2}$ per cent., consisting of phosphates of lime and magnesia, sulphate and carbonate of lime, with a small quantity of silica and peroxide of iron.

The presence of sulphur in the natural wool, amounting to as high as 3 per cent., is an interesting feature, which, however, carries with it some practical disadvantages. It is for this reason that bright and light colours cannot be dyed on wool in a dye bath made of copper or lead. This

fact is well known to practical dyers. In the Gobelins Dye Works, when under the superintendence of M. E. Chevreul, before dyeing very delicate shades, the woollen yarns were left for twenty-four hours in a bath of dilute milk of lime, then washed in fresh water and diluted hydrochloric acid, and then finally washed in clean water. This process diminishes the amount of sulphur present by one-half, and thus prevents the drawback of the wool becoming tinged brown. The presence of the sulphur in the wool manifests itself in the steaming of the printed yarns (*q.v.*), where a swatch printed with a paste containing sugar of lead or crystals of tin is changed into a brown colour, from the presence of the sulphides of these metals being formed on the fibre.

The wool as it comes direct from the sheep's back contains two impurities of special importance, *i.e.*, a large amount of natural pomatum or grease, called *yolk*, and the dried up sweat from the sheep, called *suint*. These natural oily products are of special interest to the dyer and textile colourist, because on their perfect removal by scouring and washing largely depends his success in obtaining level and beautiful shades in his dyeing and colour printing operations.

The wool grease or *yolk* is insoluble in water, but soluble in ether, benzene, bisulphide of carbon, petroleum, etc. The chemical nature of this wool fat is highly complicated, consisting as it does of cholesterin and ischolesterin, with varying quantities of the fatty acids, stearic and palmitic. Sometimes the term *wool fat* implies the two bodies combined, *i.e.*, yolk and suint, representing the total fatty matter present in the raw wool.

Pure lanoline or wool fat, which was formerly washed off and run away into the rivers, has now become utilised as a medical and toilet requisite. It is a white creamy

substance, used for making certain ointments, and forms an emollient preparation for the skin.

In its crude form it is used as a lubricant, or distilled for the making of olein and stearin.

Yolk and Suint.—The natural fatty matters present on the wool, which are soluble in water, are all included in the term *suint*. This soluble portion consists of the fatty acids, oleic and stearic, combined with potash, and smaller amounts of other different substances.

Generally the water in which raw wool has been washed shows a strongly alkaline reaction from the presence of the carbonate of potash naturally present in the wool perspiration.

In washing raw wool, therefore, this natural alkali or potash soap materially helps in the cleansing operations. What are sometimes termed "pitchy" wools are those having an excess of the fatty matters *insoluble* in water, *i.e.*, "yolk," which, being a not easily saponified fat, requires an increased quantity of the scouring materials. This explains the difficulty often experienced in scouring raw wools.

In the various processes of manufacture, wool requires to be jealously guarded against three principal dangers, *i.e.*, *excessive heat, strong alkalis, and strong acids.*

Action of Heat on Wool.—When wool is boiled for a lengthened period with water, the fibre loses its lustre, felts readily, and shows signs of slight decomposition by the traces of ammonia and sulphuretted hydrogen gas given off. In the operations of dyeing and scouring it is of the greatest importance that the wool be not kept too long exposed to the action of the heated liquids, especially in scouring where the presence of an alkali is necessary.

ACTION OF ALKALIES AND ACIDS ON WOOL.

Action of Alkalies.—Caustic alkalies, such as soda (Na HO) or potash (KHO), have a highly injurious effect on wool under any conditions. When wool is immersed in dilute warm solutions of such alkalies, it gradually dissolves, forming a soapy liquid; and this destructive action proves the great danger of the scourer using scouring alkalies, the exact nature of which he is ignorant. Carbonated alkalies for wool cleansing should be absolutely free from any caustic soda or potash. Dilute solutions of carbonate of potash or soda have very little injurious effect on the wool fibre, and can therefore be employed, with the addition of soap, for the cleansing of wool. Soap and carbonate of ammonia (sal-volatile) have the least injurious effect, and are employed in scouring the finest qualities of wool.

Action of Acids.—Dilute hydrochloric and sulphuric acids have little or no action on wool even at the boil, beyond opening out the scales of the fibre, and thereby giving it a somewhat harsh feel to the touch. Concentrated acids, however, destroy the fibre. Wool stands the action of acids much better than cotton, and this fact is taken advantage of in separating cotton from wool in rags containing both kinds of fibres. The mixed rags are steeped in dilute sulphuric acid for some time, then dried in a stove at a good heat, when the cotton fibre is completely disintegrated, and can be beaten out as dust; while the wool remains comparatively uninjured. This process is known as "carbonising" or "extracting" of rags. In printing calico, or carpet yarns, due care must be exercised in not making the printing pastes too strongly acid, or adding an excess of mordant. Such conditions render the yarn tender, and give it a harsh feel after passing through the steaming process (see chap. xiv., Figs. 14 and 15).

AFFINITY FOR COLOURING MATTERS.

Wool, unlike the vegetable fibres, has a marked affinity for certain colouring matters, especially those of aniline origin, with which it can be dyed without the assistance of any mordant. In this respect it is better even than silk. The many different qualities of wool behave differently towards colouring matters, but it is generally found to be the case that the finer qualities, and those having a high lustre, do not take the dye so readily as those of a coarser and more open nature. Mohair and alpaca, for example, are found difficult to dye.

Wools are divided into two principal divisions, *i.e.*, carding wools, and combing wools. The first are short wools, and the latter long wools. The fabrics woven from these are termed, in the first case, *woollens*, and in the other, *worsted*s, according as the one or the other is employed. Carding wools employed in the manufacture of woollens possess in a high degree the quality of felting already considered; while the combing wools employed for worsteds are not so liable to felt, and are consequently more suited for yarns, hosiery, etc. It is considered a long stapled fibre when it exceeds $1\frac{1}{2}$ inches. (For the counts of worsted yarns, and other useful data, see the Appendix.)

CHAPTER II.

YARN SCOURING—METHODS EMPLOYED—TEMPERATURE OF
SCOURING TROUGH—CLEANSING MATERIALS—STRETCH-
ING—SOFT WATER—MAGMA RECOVERY.

WOOL SCOURING.

It has already been stated that raw wool, as it comes from the sheep's back, is in a greasy condition from the presence of certain fatty matters. Wools in this raw state are technically known as *in the grease*. This natural grease must be completely removed by the process of scouring with soap and weak carbonated alkalis before the wool can be dyed or printed. It is of the utmost importance that the cleansing of the wool be thoroughly well done, otherwise poor, uneven dyeing and unsatisfactory colours are the result.

After the raw wool has been cleansed it requires, before being spun into yarns, the addition of a certain amount of oil. Wollen yarn and cloth contain olive oil, oleic acid, or an emulsion which is sprinkled on the fibre as it is being spun. This oily matter must again be removed by scouring agents before the yarn is ready for dyeing or bleaching.

Before wool scouring machines were introduced the operation of hand scouring was a very laborious and at the same time an unpleasant task. Stale urine, or *lant* has been employed from the earliest times for this purpose, and its efficacy as a detergent is due to the carbonate of ammonia which it contains. Wool scoured with lant possesses all its natural softness, lustre and elasticity, but the disagreeable

smell imparted to it is an objection. The subject of wool scouring has received, for over a hundred years, more attention on the continent than in our own country. As an interesting fact, showing with what religious care the subject was treated in Germany over a hundred and seventy years ago, it may be stated that the ministers were ordered to read from the pulpits the most approved methods of wool scouring and sorting. (See *Southy on Colonial Wools.*)

Woollen and worsted yarns, when received from the spinners, contain the oil which is purposely added to facilitate the spinning operations. In this oily condition the yarn is quite unsuited either for dyeing or colour printing, as the oily surface of the fibre prevents the proper absorption of the colouring matter. The removal of this spinner's oil necessitates the operation of scouring with soap and weak carbonated alkalis. The weight of the oil present in carpet yarns varies according to the quality of the wool and the nature of the yarns—whether woollen or worsted; but it is generally understood that from 6 to 10, or even in the heavier yarns as high as 15 per cent. is the usual amount. In the case of worsted yarns 10 per cent. is the average, and 15 per cent. in woollens. Should it however exceed this, it may be considered as unduly weighted with oil. This excessive weighting of yarns with oil is a great objection, and forms an important feature in the selection of a yarn. It causes an unnecessary increase in the expenditure of soap and scouring liquid, in order to effect its complete removal. Hence arises the necessity for all carpet manufacturers to make a preliminary test always before buying a yarn in its oily condition, in order to see that it is not overweighted with oil. From the loss in weight of the wool, after careful scouring and drying, it is easy to calculate the percentage of loss, which represents the amount of oil that was present in the yarn. In practice it is found that some yarns scour much easier than others,

owing to the nature and quantity of the oil used in their spinning. If the oil used be a glyceride, such as olive oil, saponification is easily accomplished, but if it belongs to the hydro-carbon or mineral series of oils, as sometimes employed in the lower class yarns, saponification is rendered more difficult, according to the proportion of mineral oil present. The exact quantities of the scouring agents required for the complete cleansing of a yarn is therefore only gained after a few experimental trials. The employment of an emulsion or a neutralised solution of sulphated castor oil for the spinning of yarns has been in use for some time, both in this country and on the continent. Yarns spun with this emulsion, or soluble oil, have the great advantage of requiring little soap for their cleansing; in some cases a wash in clean warm water being sufficient to remove all impurities. It is readily seen that a considerable saving in scouring materials would be effected if this soluble oil or emulsion spinning became more general. The thorough cleansing of a yarn in scouring is of as much importance in carpet making as in dyeing. If this be not properly performed, either from an insufficient quantity of soap or too hasty manipulation, the colours in the printing do not fix equally on the fibre, and blotchy, uneven work is produced. The colours of an important pattern may receive the careful attention of the print master during the printing process, and every care be taken to have them level in tone; yet the pattern may turn out uneven and "stripey" in colour from this insufficient scouring. It is difficult to lay down hard and fast rules regarding the scouring of carpet yarns, as they differ so widely in quality of fibre and percentage and nature of the oil used in spinning. The proportions of scouring materials have accordingly to be altered to suit the requirements of the particular yarns.

Scouring Machine.—The scouring of the yarn may be done solely by the hand, by shaking the hanks to and fro several

times in the soapy liquid; or it may be better and quicker performed by a scouring machine, either in the loose hank method or in the continuous chain. The scouring machine consists of a rectangular box or tank fitted with a series of rapidly revolving reels or racers, on which the hanks of yarn are suspended into the scouring liquid. The accompanying illustration, from Ainers, Galashiels (Fig. 2.), shows clearly the construction of a good carpet yarn scouring machine. The gear wheels for driving the feed rollers (seen to the left) have on a protective covering or case when working; the illustration shows this case removed. The cast iron tank in front of the press rollers measures 5 ft. 6 in. long, by 2 ft. 6 in. wide, by 2 ft. deep inside; and is fitted with three reels or racers on the top for turning the yarns in the scouring liquor. The racer stays are made of brass rods, fitted into cast iron ends; each racer being keyed upon a steel spindle and operated from the driving gear of the press rollers. An outlet valve is fitted in the bottom of the tank to run away the spent soapy liquors. These dirty soapy liquors are afterwards utilised (see the Magna process).

Temperature of the Scouring Bath.—The temperature of the scouring bath is an important consideration. It should be about 100° to 110° F., or not too warm, but the hand can be held comfortably in it. A higher heat than this hurts the lustre of the wool, and renders the yarn liable to become “felted”. This felting of the yarn in carpet making is a serious danger; causing much trouble in the various operations it has yet to go through. For quick scouring a higher heat is necessary, but such a method is not to be recommended, as it only saves a little time at the expense of the “feel” and lustre of the wool. In wool scouring it is well to remember that the lower the temperature at which the scouring bath can be used, consistent with thorough and efficient cleansing, the better for the lustre and “feel” of the yarn.

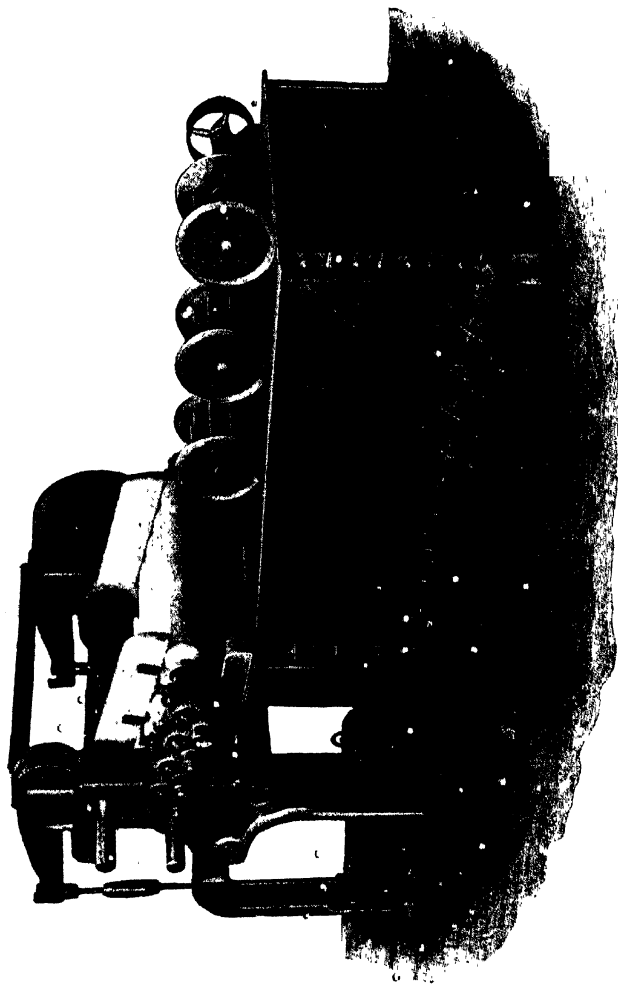


Fig. 2. Scouring Machine (Aimers).

Methods of Scouring.—The yarn is usually scoured in batches of 100 lb. each, each hank being treated individually on the swifts or reels of the scouring machine; or they may be scoured by the chain method.

Chain Scouring.—Instead of treating each hank individually, they are linked together by means of pieces of cord, one hank being tied to another in chain fashion. This chain of hanks is then scoured by running continuously through the scouring trough. What is rather an objection to this method is that, at those points where the hanks are attached to each other by the cord, the yarn is apt to become tight and compressed. This has a tendency to prevent the scouring liquid from acting so freely at those points of contact as in the body of the hank where the yarn is free. The scouring has a chance of not being so well performed as when each hank is loose and receives individual treatment.

For the finer classes of wools the following proportions may be given for scouring 100 lb. of yarn :—

2 lb. Mild Potash or Marseilles Soap.
2½ to 3 lb. Carbonate of Potash K_2CO_3 .

This forms the first bath, and after it has been treated sufficiently long, it is passed into scouring bath No. 2, which consists of soft warm water and just sufficient ammonia to smell plainly of it. After treatment in this second bath, the finer yarns are sufficiently cleansed.

Where a potash soap is used, it is always considered better to use carbonate of potash or pearl ash (K_2CO_3), instead of carbonate of soda, when such alkalies are required.

In scouring with the heavier carpet yarns, a good soda soap made from olive or cotton seed oil or tallow gives very satisfactory results at about the rate of—

2 to 2½ lb. hard soap,
6 lb. soda crystals, or
2 lb. patent alkali, 98 per cent.
50 gallons water

for 100 lb. of yarn.

This constitutes scouring bath No. 1, and when the hanks have been treated sufficiently long in it, bath No. 2 is prepared with pure water as before, and 2 lbs. soap, with the addition of a little ammonia. The dirty soapy water, after bath No. 1 has been used, is run off into a large collecting tank, where the fatty matters are recovered. After the yarn hanks have been run through No. 2 bath, they are taken off the revolving reels or racers and thrown upon the "feed rollers," when they pass through the squeezing rollers and come out behind, where an assistant stands ready to receive them. The squeezing rollers are covered with a good quality of india rubber, known as para-rubber, of about one inch thick. The top and bottom rollers are geared to each other, so that when the yarn hanks are thick, there will be no slipping of the rollers, which would cause the yarn to become cut and damaged.

Some varieties of yarn, more especially those of high lustre, have the awkward property of twisting and curling whenever they are brought into contact with warm water, and unless something be done to prevent this, the whole hank becomes twisted and entangled. In such cases, resort has to be made to the process of "stretching," before the scouring. This is accomplished by having the hanks of yarn tightly stretched on a framework of poles, and then they are immersed in boiling water for half an hour. By doing so the yarns lose their property of curling, and can be scoured without further trouble.

Standard Scouring Solutions.—The various soap and soda solutions are usually kept, for convenience, ready prepared, at the rate of 1 lb. to the gallon of water.

Carbonate of ammonia is the ideal scouring agent for wools, and one of the best detergents when in combination with soap; but it is too expensive to use in the industrial scale. For ordinary carpet yarns, the most largely employed

scouring agent is carbonate of soda (*q.v.*). Nearly every carpet work has its own special formulæ for making scouring solutions, and each one, perhaps, differing in a few details, according to the special requirements of the class of work.

The following method of working, found in practice in one of our large carpet works, may be taken as a very good example of how carpet yarns are generally scoured.

The following standard solutions made with pure condensed water, are prepared and kept in separate tanks:—

Standard Scouring Solutions.

I. *Standard Carbonate of Soda Solution.*

1 lb. Refined alkali, 98 per cent., Na_2CO_3 per gallon water, stands 18° Tw.

This equals about 3 lb. soda crystals ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$) per gallon.

II. *Soda and Soap Solution.*

$\frac{1}{2}$ lb. refined alkali, $\frac{1}{2}$ lb. good hard olive oil soap, per gallon of water.

III. *Standard Soap Solution.*

This is made of a good olive oil, tallow, or cotton seed oil soap, at the rate of—

- 1 lb. soap per gallon water.

• *First Scouring Bath for 100 lb. yarn.*—Into scouring trough holding, say, 40 to 50 gallons water, add 4 gallons No. II. solution, representing 2 lb. soap and 2 lb. carbonate of soda, 98°, 1 gill strong ammonia. After the yarns are sufficiently scoured in this bath, it is run off and bath No. 2 prepared.

Second Scouring Bath.—Into same quantity of water as before add 2 gallons of No. III. solution, representing 2 lb. soap. Scour the yarn in this as before.

This second bath is kept and converted into bath No. 1 for the next lot of a 100 lb. by the addition of from 2 to $2\frac{1}{2}$ gallons soda solution No. 1, and 1 gill ammonia.

This makes it into bath No. 1, and is ready for the next new lot of 100 lb. dirty yarn.

It is left to the scourer to add a little more soap and soda solution, as required, to keep up a good scouring "graith," or sud; and so the scouring goes on all day long, the finishing bath of the one lot being made into the first scour of the second lot. If the yarns be spun with olive oil, oleine, or cloth oil, or the emulsion already mentioned, they require a less amount of scouring materials. The proper proportions for each case is only arrived at after a little experience. It is better for the yarns to be again washed in a tank of clean water to remove any trace of alkali before submitting them to the bleaching process; but in many carpet works this third washing is dispensed with, owing to the extra time and space it requires.

The quantities of soap and carbonate of soda necessary for efficient cleansing of the yarn vary with the quality of the yarn. It must be left to the judgment and experience of the scourer in charge to add sufficient soap in order to keep a good "sud". The yarns which, in the language of the factory, are found to "kill the soap," or what are termed "pitchy," are only found by experience.

In wool scouring it must ever be borne in mind that the cleansing *must be accomplished by the mildest means possible.* The natural elasticity, softness, strength and openness of the fibre must be retained; and this cannot be done if little attention be paid to its manner of treatment and the materials employed during the scouring operations.

Soft Water for Scouring and preparing the Solutions.—In the dissolving of soaps for scouring it is necessary to pay careful attention to the water employed, which should be as free as possible from calcium and magnesium salts. Whenever these salts are present, and in some waters they are to a high degree, the disagreeable lime and magnesia soaps are formed, which

not only consume soap but adhere tenaciously to the fibre, giving it a less agreeable feel. A good plan, which might be adopted by most works, is to have a large store tank above the scouring department for collecting all the condensed water throughout the factory. This tank is then kept filled with soft water, which can be used for making up the standard soap and alkaline solutions and for scouring purposes. By doing this a very considerable saving in soap is effected; the yarns are better scoured and feel softer, and the formation of any lime and magnesia soaps is avoided. The important subject of water is specially treated in chapter iv. After the yarns have been thoroughly cleansed they are ready for the bleaching (see chap. v.).

Magna Process, or Waste Soap Recovery.—The dirty soapy liquids from the scouring are run into large tanks or vats, either of stone or wood, lined inside with sheet lead. Here they are acidified with sulphuric acid, when all the fatty matter of the soap, and of that scoured from the yarn, rises to the surface as a thick grease or magna. This is allowed to stand for some time, when the clean water may be run off, and the grease drained on woollen filters. This grease can be sold to oil dealers, or it may be made into a lower quality of soap, known as "recovered" soap. In the tapestry carpet trade this grease may be added to the dressing batter instead of oil. This prevents the dressed jute from adhering to the copper drying cylinders over which it passes. It is considered better than oil for this purpose, and gives to the back of the tapestry carpet that soft "leathery" feel which is considered an advantage.

CHAPTER III.

SCOURING MATERIALS—POTASH AND SODA SOAPS—CARBONATES OF SODA, POTASH AND AMMONIA—PATENT SCOURING COMPOUNDS.

As the scouring of wool is one of the most important questions to the textile manufacturer, it may be of advantage to devote a short chapter to the materials employed in wool scouring.

Scouring Soaps.—The quality of the scouring soap employed in cleansing the yarns is a question which requires careful attention. With the finest qualities of wool a mild potash, Marseilles or Castile soap (which is an olive oil soda soap) or Oleic soap are perhaps the most suitable; with the addition of a little ammonia to the bath if necessary to improve their detergent effect. With the heavier and coarser yarns, such as those generally used in tapestry carpets, a good soda soap is excellent; assisted with the addition of a little pure carbonate of soda. This is required in order to cleanse them thoroughly. Good scouring soaps are made from tallow, olive oil, palm and cotton seed oils, and to be neutral should have ten times the amount of fatty acids to that of combined alkali. A cocoanut oil soap is more caustic than ordinary white or yellow soaps, and contains an excessive amount of water, generally 73 per cent. or nearly $\frac{3}{4}$ of its weight of water. The presence of adulterations such as potato flour, silicate of soda, china clay, rosin, etc., must be guarded against. Rosin in scouring soaps has now been found to be a fruitful source of uneven dyeing and colour printing; and as it is about a

quarter of the price of tallow, its presence greatly lowers the commercial value of a soap. Commercial soaps are sometimes designated as 60 per cent., 63 per cent. or 65 per cent., which represents the percentage of fatty matters combined with the alkali.

The following analyses may be taken as examples of good scouring soaps :—

	No. 1 Good White Soap	No. 2 Olive Oil Soap	No. 3. Cotton-Seed Oil Soap.
Fatty Acid - - - - -	60.00	64.00	68.34
Combined Soda - - - - -	6.40	6.94	6.23
Water - - - - -	33.60	24.10	22.18
Sodium Chloride and Sulphate, etc.	—	4.66	2.95
	100.00	100.00	100.00

Potash Soaps.—It is generally admitted by the best authorities on wool scouring that potash, either in the form of a potash or soft soap, or carbonate of potash, K_2CO_3 , has a milder effect on the wool fibre than soda. Hence for the fine wools a potash soap is to be preferred to a soda one for scouring. This would seem to be indicated by Nature, as from the analyses by Chevreul and others of the wool fat or “yolk” present in the raw wool (see chap. i.), it is seen to contain a large percentage of potash salts, with only a trace of soda.

The following is an analysis of “Yolk” ash :—

Potassium Carbonate	86.78
Potassium Chlorides and Sulphate	9.01
Soda, Lime, Magnesia, Iron, etc.	4.21
	100.00

A potash soap is known as a soft soap, while a hard soap containing soda as the alkali. Potash soaps are deliquescent, and are therefore liable to vary in the proportion of water

they contain.' A good potash soap for wool-scouring is made from various oils such as olive, cotton-seed, linseed, etc., in combination with tallow. The following analysis, given by Rawson, represents the usual composition of a soft soap.

Analysis of Potash Soap :—

Fatty Acid	43.78
Combined Potash	9.20
Potassium Carbonate, etc.	1.27
Glycerine	3.55
Water	42.20
	<hr/> 100.00

A potash soap, with an addition of a little ammonia to the scouring liquid, forms one of the finest cleansing agents for wool that can be used.

Soda Soaps.—(Hard soaps) when free from excess of alkali and adulterants such as have already been mentioned, form excellent scouring soaps. "Yellow" soaps are, however, to be carefully avoided, as they contain varying quantities of rosin, which is unsuitable for wool-scouring. Many cases of stripey dyeing and uneven printing have been traced to a rosin soap employed in scouring the yarn. The general composition of a good soda soap is found to be as follows :

Good Soda Soap (for scouring) :—

Fatty Acids	64.11
Combined Soda	7.07
Carbonate Soda32
Water	28.50
	<hr/> 100.00

The commonest varieties of soda soap are known as curd, yellow and mottled. In many districts mottled soap in combination with carbonate of soda is largely used for yarn scouring. Soaps which on analysis show the presence of uncombined or "free" caustic alkali should be rigorously avoided, as they destroy the lustre of the wool fibre and impair its qualities. An excess of carbonated alkali is,

however, not injurious, but in some cases considered an advantage.

A good olive oil soda soap, having a composition similar to No. 1, given at the commencement of this chapter, has been found by experience to give excellent results.

Carbonate of Soda.—For scouring carpet yarns a pure carbonate of soda, such as found in “refined soda ash” or “patent alkali,” containing 98 per cent. pure sodium carbonate, Na_2CO_3 , has met with marked success among woollen manufacturers and scourers. It is absolutely free from any caustic soda or lime, which is a feature of much importance in wool scouring. Carpet yarns scoured with this pure carbonate of soda feel soft, and keep their lustre better than when inferior carbonates are used. It may be considered three times stronger than soda crystals, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$.

Commercial sodium carbonate comes into commerce in various strengths—48°, 56°, 58°—each degree representing the percentage of sodium oxide (Na_2O) present. “Pure alkali” or “soda ash” is a very pure form of the carbonate guaranteed 58°, which represents 58 per cent. sodium oxide, or 99 per cent. carbonate of sodium. A good sample should be free from colour, residue and from iron compounds.

Carbonate of Potash (K_2CO_3), is employed in scouring the finer qualities of wools, and is largely used in the manufacture of soft soaps. Potash is considered by all wool experts to be the best alkali for wool scouring, but in most cases, especially with the common carpet yarns, carbonate of soda is used, as it gives excellent results and is much cheaper.

Carbonate of Ammonia has already been mentioned as the ideal scouring agent, as, being volatile, it leaves the fibre perfectly pure, but its expense prohibits its general use.

Ammonia (NH_3) forms a valuable addition to the scouring bath, and its detergent properties, in combination with

soap, give a beauty and lustre to the wool, unattainable with the carbonate of soda alone.

The ammonia liquor (NH_4OH), which is the gas dissolved in water, has a specific gravity of '880; that is, it is lighter than water, which stands 1', and the lighter the solution the more ammonia gas it contains.

For table of specific gravity and percentage of ammonia in ammonia liquors see Appendix.

Scouring Compositions.—Many patent scouring compositions are found in the market and sold under various names. They are all composed more or less of a mixture of carbonates of soda or potash with soap. They are all good enough in their way; but could be manufactured by the consumers themselves at a much lower cost. Secrets in scouring compounds belong rather to the age that is happily past and gone, than to the present day, but as long as they find a market they will find a maker.

CHAPTER IV.

WATER—HARDNESS, TEMPORARY AND PERMANENT—WATER FOR SCOURING PURPOSES—CHEMICAL PURIFICATION BY LIME AND CAUSTIC SODA METHODS.

As the nature of the water employed in a dye or print work is a question of some importance, we shall devote a few pages to its consideration. The impurities which concern the dyer and colour chemist are either in *suspension*, or *solution*. The *suspended* impurities can easily be removed by filtration, but those in solution have a more injurious effect, and are, at the same time, more difficult to remove. As a rule, spring and well water contain the largest amount of substances in solution.

Water for technical purposes is generally divided into three classes, viz., soft, medium hard, and hard, and those are: (1) rain water; (2) river and surface water; (3) well and spring water. What is termed the "hardness" of a water is the property it has of destroying, or "killing," the lather of soap. The degree of hardness of a water is an important consideration to the textile manufacturer and to the scourer, as every degree of hardness completely destroys nearly $1\frac{1}{2}$ lb. of soap in every 1000 gallons of water. Hence, after a year's working in a large mill, there is a very considerable balance in favour of those having a soft water. The hardness in water is caused by the lime and magnesia in solution.

CALCAREOUS AND MAGNESIAN IMPURITIES.

The *calcium* or lime salts in solution are detected by adding to the sample of water a few drops of ammonium oxalate and ammonium chloride. A fine white precipitate is produced.

Magnesia Salts.—After the water has been treated, as for calcium salts, with oxalate of ammonia and chloride of ammonia, the water is boiled and filtered, and the filtrate evaporated down to about $\frac{1}{10}$ of its bulk, then add a solution of sodium phosphate and ammonia, when a crystalline precipitate shows the presence of magnesia salts.

The presence of *sulphates* is shown by a white precipitate on addition of a few drops of hydrochloric acid and barium chloride to the water.

The presence of *chlorides* in a water is shown by the white curdy precipitate on adding a few drops of nitric acid and nitrate of silver.

HARD WATERS only produce a froth suitable for scouring purposes after all the lime and magnesia have been precipitated in the form of disagreeable lime or magnesia soaps which are insoluble in water. These earthy soaps are more or less of a sticky nature, and adhere tenaciously to the wool fibre, causing it to take on the colours unevenly at those parts. This property of destroying the lathering properties of soap forms the basis of the test for hardness known as Clark's method.

By employing a solution of a pure 'soap' of 'standard' strength it is possible, by adding it carefully to a sample of water, to calculate from the amount of soap solution consumed before a lather is formed, the amount of calcium and magnesium compounds present in the water. (For details of this method consult text-books of chemical analysis.)

There are two kinds of hardness, technically known as "temporary" and "permanent".

Temporary Hardness.—It will be noticed that on boiling a hard water for some time, a certain amount of its hardness is removed. This is due to the fact that soluble acid carbonates of lime and magnesia have been present in the water, and these become decomposed in the boiling; the carbonic acid gas, which rendered them soluble, escapes as a gas, while the normal insoluble carbonates are thrown down in the form of a white flocculent precipitate. If this water be in a boiler or a kettle, the precipitate accumulates gradually, and forms the "furring" of the kettle, or the "scale" of the steam boiler. This hardness, which is removed by boiling, is termed the *temporary* hardness, while that hardness the water still possesses after prolonged boiling, is distinguished by the term *permanent*. The two combined give the *total* hardness. The salts which mainly give rise to permanently hard waters are the sulphates of lime and magnesium.

Water for Scouring Purposes.—From what has already been stated it will be seen that the nature of a water is of much importance in the scouring operations, where the presence of lime and magnesia is objectionable. No cleansing action of the soap takes place until these salts are first precipitated as lime and magnesia soaps. Pure soap may be regarded as a combination of potash or soda with a fatty acid (oleic, stearic, palmitic, etc.). Where lime is present this pure soap is decomposed,—the fatty acid combining with the lime, forming a lime soap, and leaving the soda in solution. This process of precipitating the salts of lime and magnesia is termed "softening," and in the present case the water is softened at the expense of the soap. This shows the advantage of manufacturers collecting the soft or the condensed pure water throughout the mill and storing it in tanks, to

be utilised for scouring purposes, making the standard soap solutions, and dissolving some of the aniline dye stuffs. It has been found from actual experiment that a certain hard water used for scouring yarns destroyed in 1000 gallons no less than 50 lb. of good soap before it was sufficiently softened for scouring purposes. The importance of this to yarn scourers requires no comment.

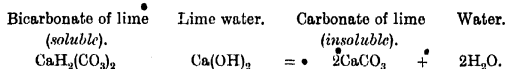
Iron is sometimes present in waters in considerable quantity, and for certain classes of work is highly objectionable. Dyers, for instance, cannot get clear and bright colours where iron salts are present. It may be detected by evaporating a quantity of the water nearly to dryness, with the addition of a few drops of pure nitric acid. If a drop of ferrocyanide of potassium solution be then added a blue coloration will be produced. A slight coloration on adding a few drops of tannic acid shows the presence of iron salts.

A hard water is not suitable for dissolving many of the aniline dyes, especially those of basic nature like methyl violet, basic green, etc., as the lime or magnesia precipitates a portion of the colour base in the form of tarry, sticky particles. This not only causes a portion of the colouring matter to become lost, but gives rise to specks in the colour, causing the goods to be spotted. A water rich in bicarbonates is especially unsuitable for this purpose. The addition of 1 part of vinegar to 1000 of water corrects this and prevents mischief.

Chemical Purification. — A common method of 'softening' water is that devised by Dr. Clark, which depends upon the precipitation of the calcium and magnesium by means of lime.

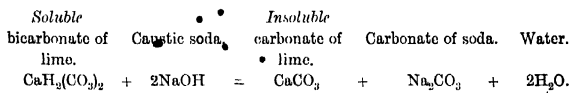
This process is, of course, only applicable where the hardness is due to bicarbonates, or where an excess of carbolic acid is present in the water, rendering the lime and magnesia

carbonates soluble. The process may best be explained by the following equation :—



This is the theoretical reaction which takes place, but unfortunately in practice it is found that difficulties are met with, and the process requires the most careful attention. A slight excess of the theoretical amount of lime water will, of course, render the water harder than ever. It is considered best to employ clear lime water for this purpose, as it possesses a constant and known composition. Milk of lime, on the other hand, is uncertain in strength.

Purification with Caustic Soda.—In many cases it is more advantageous to employ caustic soda (NaOH) instead of lime water, as in the Clark process. For purposes of scouring and washing, where a slight excess of alkali in the water does no harm, this is specially recommendable. It is better if the water during this treatment be gently heated, in order to facilitate precipitation of the insoluble carbonates of lime and magnesia. The reaction which takes place is as follows :—



Any other impurities which may be present in the water, such as alumina, magnesia, iron and earthy phosphates are completely precipitated in this way.

Treatment with caustic soda removes the *permanent* as well as the *temporary* hardness, as the sulphates of lime and magnesia are in their turn decomposed by the carbonate of sodium formed during the first part of the reaction given above.

CHAPTER V.

BLEACHING OF CARPET YARNS.—GAS BLEACHING OR STOVING —WET METHOD—HYDROGEN AND SODIUM PEROXIDE.

AFTER wool is scoured it has more or less of a yellowish tint, from the presence of natural colouring matters in the wool fibre. In many cases the yarn in this condition is quite suitable for the purposes required, as when the colours to be dyed or printed do not require to be specially matched. But when a pure white yarn is necessary, it requires to be bleached, or what is often termed "stoved". In printing carpet yarns, where clear and accurately matched colours is a great desideratum, this bleaching process is absolutely necessary. The bleaching agent almost universally employed is sulphurous acid, either in the gaseous state, obtained by burning sulphur, or in solution. Within the last few years, however, hydrogen peroxide (H_2O_2) has been growing in favour as a wool bleaching agent. These three methods will be considered.

Gas Bleaching or Stoving.—This is done by the action of sulphur dioxide (SO_2), either in the dry gaseous state, or, in the wet way, by its liberation from bisulphite salts in solution. The former method, or what is known as "gas bleaching" or "sulphuring," is the one most generally adopted among carpet manufacturers. It is well to remember that the action of sulphur dioxide (sulphurous anhydride) in bleaching is one of reduction and not oxidation as in the case of chlorine or hydrogen peroxide

bleaching. The sulphur dioxide unites with the oxygen of the colouring matter present in the fibre, reducing or deoxidising it to form a colourless compound. What the chemical nature of this natural colouring matter is, has not yet been determined. If the yarn after scouring be not properly freed from all alkaline or soapy liquid, a certain amount of sulphurous acid must necessarily become lost in neutralising this alkalinity before the bleaching action can begin. This shows the advantage of giving the scoured yarns a final wash in water before bleaching. The yarn, after being thoroughly cleansed, is conveyed to the bleaching chambers in the moist or wet state, where it is left to the action of the sulphur dioxide gas, produced by burning sulphur in an iron crucible which is placed in a corner of the chamber. These sulphuring chambers require to be spacious in order to give room for the yarn hanging on the poles to be sufficiently spread out, and each hank kept separate, so that the fumes of the gas may have free access to the yarn. If the yarn poles be crowded closely together, each pole of hanks tightly pressed against its neighbour, the gas is prevented from penetrating the yarn, and the bleaching cannot be properly performed. This may prove a source of unsatisfactory and "stripey" bleaching. Free access to all parts of the yarn must be given to the gas if the bleaching has to be well done, and full advantage taken of the sulphur consumed. The bleaching chambers may be built either of brick or wood, but if built of brick it is necessary to line the walls inside with wood to protect the brick and mortar from the action of the sulphurous fumes. Sulphur dioxide so acts on the bricks and lime as to disintegrate them in course of time, and the walls become shaky and the bricks loose. This strange disintegration is caused by the formation of minute crystals in the form of an efflorescence, consisting of a double ferrous aluminium

sulphate, of the formula $\text{Al}_2(\text{SO}_4)_3 + \text{FeSO}_4 + 24\text{Aq}$, which grows out of the brick and mortar.* The yarn is allowed to remain in this atmosphere of sulphurous gas for from six to ten hours, according to the degree of whiteness required. The last batch of yarn to be bleached for the day is left in the chambers overnight. The amount of sulphur required is generally taken at from 5 to 7 or 8 per cent. of the weight of yarn to be bleached. The quicker the bleaching the more sulphur is required. In the proper management of the bleaching process it is necessary to pay careful attention to the heat of the iron ball used for igniting the sulphur, and to the admission of air into the chamber during the burning of the sulphur.

The usual dimensions of the sulphur-stove is 5 to 7 feet broad, by 8 or 10 feet long, or longer if necessary; and 6 feet or so high. If the yarn be hung in two tiers, one above the other, the chamber may be 10 feet high. It must be remembered that too roomy a chamber is unnecessary, as it only causes expenditure of more sulphur to fill it with the sulphurous fumes.

Heat of Iron Ball.—The iron ball, weighing generally about 38 lb., should never be cooler than a clear cherry-red heat to burn completely all the sulphur. If a lower temperature be used it is often found that a quantity of unburnt sulphur still remains in the crucible. Accordingly an insufficient amount of sulphur dioxide must have been produced, and poor, faulty bleaching is the result.

Admission of Air.—The other important point is the admission of air into the chamber, through a little trap-door, during the burning of the sulphur, to enable the combustion to be kept up until the sulphur is consumed. If air be not admitted in some way, the burning sulphur is simply ex-

* See *Trans. Chemical Society*, D. Paterson, 1896.

tinguished some time after the doors are shut for want of oxygen; and the same unfortunate results are obtained as those just already stated, viz., a quantity of sulphur is left unburnt and the yarn is insufficiently bleached. After such an occurrence the purity of the sulphur has been questioned; but the true cause, almost without exception, lies with these two points—the heat of the igniting ball, and the proper admission of air. When the yarn has been exposed long enough to the bleaching action, which is generally from six to ten hours, according to the degree of whiteness required, the doors are opened and the chambers well ventilated. The yarn is then taken and washed or steeped in clean water to remove the sulphuric and sulphurous acids present in the fibre; after which it is conducted to the hydro extractors, where all superfluous water is removed. After a thorough drying in heated chambers called the “drying stoves,” it is ready for receiving the colour in the printing process.

Bleaching by the Wet Method.—This consists in steeping the yarns sufficiently long in a solution of sulphurous acid (H_2SO_3) or of sodium bisulphite to which sufficient hydrochloric acid has been added to liberate the sulphur dioxide. Another method, which is considered better, is to work the yarn first in the bisulphite solution, then pass it into a separate acid bath, i.e., hydrochloric acid at 2° Tw., thus liberating the SO_2 gas in the nascent state within the fibre. Theoretically this is the best method, and should give the most satisfactory results, as the nascent gas acts more powerfully on the natural colouring matter present in the fibre.

There is, however, one disadvantage of such methods. The liberated sulphurous gas permeates the atmosphere of that department of the work, and the gas has an injurious effect on the health of the workers. The bleaching action also seems to take longer than by the gas method.

Hydrogen Peroxide (H_2O_2).—This is now becoming used as a bleaching agent for the fine qualities of wools. The yarns are steeped several hours in a slightly alkaline solution of hydrogen peroxide, and afterwards well washed.

Unless for special purposes, and for certain goods its use is somewhat limited owing to its expense. Another method recommended is to steep the yarns in an ammoniacal solution of hydrogen peroxide, then take out, wring, and allow to dry in the air.

Sodium Peroxide is, however, coming more into use, as from it the preoxide of hydrogen may be produced immediately by the consumers themselves by the addition of acid to the sodium peroxide solution. The yarns must first be well scoured before entering the bleaching bath. The general process for bleaching from 100 to 150 lb. yarn by this method is as follows :—

A bath is made up with

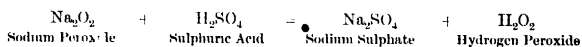
1000 gal. cold water,
8 lb. strong sulphuric acid,
3 „ phosphate of ammonia,
7½ „ sodium peroxide.

The ingredients are put into the bath in the order given above. The bleaching tank may be made of wood, earthenware or lead, but no iron, copper or tin must come in contact with the bleaching liquid. After the first 100 to 150 lb. yarn is bleached the bath may be renewed by the addition of

8 gal. cold water,
2½ lb. sulphuric acid,
1½ „ sodium peroxide,

when it is ready for another 100 to 150 lb. yarn. If the bath shows any indication of acidity this must be overcome by the addition of a little liquid ammonia to render it slightly alkaline. In the acid state the oxygen is not evolved readily, so it is of importance to pay attention to the alkalinity of the

bath. If the bleaching is to be done quickly the water may be used at a blood heat for wools; the time required being from three to twenty-four hours, according to the strength of the bath and the degree of whiteness required. The bleaching action in this hydrogen or sodium peroxide process is one of *oxidation* and not reduction as in the sulphur dioxide methods. The reaction which takes place may be simply explained by the following equation:—



The H_2O_2 readily gives off its spare atom of oxygen to the colouring matter of the fibre, and then becomes water, H_2O . Theoretically, it forms an ideal bleaching agent; it leaves the yarns beautifully white and soft, but the slightly increased cost of bleaching by this method prevents its ready adoption into the carpet industry.

CHAPTER VI.

INTRODUCTION TO COLOUR-MAKING FOR YARN PRINTING—THE COLOUR CHEMIST—COLOUR-SHOP—GENERAL TREATMENT OF DYE STUFFS.

AFTER the preparatory operations of scouring and bleaching already described, the carpet yarn is then in a suitable condition for receiving the colour. In what is termed "hank" printing (see chap. xi.), the yarn is prepared with chlorine, but in tapestry carpet yarn printing such preparatory treatment is unnecessary. The printing on of the colours in their correct places, according to the design of the carpet pattern, is done in the print shop by mechanical appliances yet to be described. The term "colour" here is used in the same sense as in calico printing, namely, a mixture of colouring matters, mordant and thickening, which, when printed on the yarn and steamed, dyes the wool and produces the colour of the carpet. The preparation and mixing of the colours with suitable ingredients and mordants to make any desired shade is termed the "colour-mixing," and forms the essential part in tapestry carpet colouring. This department is under the direction of the colour chemist, who, if he be a suitably trained man, has also the supervision of the other operations in the works where chemical knowledge is required, such as the bleaching, scouring, examination and selection of scouring soaps, the proper recovery of waste soapy liquors, the purification of waste dye waters, etc. A well-equipped laboratory is most essential, wherein all experimental work and colour

testing can be performed. The daily work of the colour chemist consists in making examination and comparative dye tests of new colour-stuffs introduced from time to time, in testing the purity and strength of the dyes and drysalteries received, making any new shades required and matching the various colours which are made during the day. Another important branch of colour chemistry, which in this country is apt to be neglected, is the experimental research work. This comprises the investigation into the many causes of irregularity which appears in the printed colours, the effect of different mordants in the printing and steaming, their effects on the wool fibre, the working out of new colour recipes and cheaper methods of preparation. These and many others are interesting and important questions to every colour chemist. New deliveries of colour-stuffs are tested before being put into use, by comparing their strength and purity with standard samples kept in the laboratory. Every new lot or "batch" of colour made is printed as a trial on a small quantity of yarn termed a "swatch". This is steamed, washed and dried, and then compared with the standard shade preserved in the colour-book. To the colour-maker this book is invaluable, as it contains standard duplicates of every shade used. If the newly made colours prove a little off the "standards," they must be altered by the addition of the proper dyestuff to bring them to the correct shade. This matching, or examination, of the colours forms the most important duty of the colourist, and often he finds it no easy task before a perfect match can be obtained. The quality of the daylight, the nature and behaviour of the colours examined, the fibre or material on which the colour is dyed, all affect to a marked degree the general appearance of shades. After long experience, dyers and colour-mixers can tell very closely the exact amounts of colour ingredients necessary to give the precise shade.

The Colour-shop.—The colour-shop is best divided into three departments: first, the colour-shop proper, where the colours are made, and standard dye-solutions kept and measured out as required; second, the stock-rooms, where all the prepared colours are stocked in tubs and barrels ready for use; third, the store-rooms, where all the dry-salteries and colour-stuffs used in the colour-making are stored and weighed out. This department requires to be comfortably warm in winter time; as many colours in the paste form are deteriorated by the action of frost. The “mixing-house,” or where the colours are made, is fitted up with one or two sets of steam-jacketed copper boiling pans. A set generally consists of three pans, varying in capacity from 10 to 40 or 50 gallons. These are used when dissolving the dyestuffs for making standard dye-solutions, or for thickening colours by boiling them with flour. The admission of open steam is often not desirable in such cases, as the formation of water by condensation would accordingly dilute the colour. The admission of steam into the outer casing of the pans can be regulated by crans, and when steam is shut off cold water may be made to circulate inside, and thus the colours are quickly cooled. This tedious task of boiling and cooling the colours, which requires continual stirring, is generally assigned to the “gum sticks,” *i.e.*, boys or young apprentices of the colour-shop. Each pan is suspended on pivots, to enable them to be easily tilted over and emptied of their contents.

Weights and Measures.—It is to be regretted that the English system of weights and measures is still generally employed in the manufacturing processes in this country, instead of the simpler and more scientific French decimal system of *grams* and *litres*. This is especially so in such branches of industry as dyeing, calico printing, and carpet-colour mixing, where chemical knowledge and scientific

methods are of advantage. For a series of useful tables see Appendix.

Weights.—The weights employed in the colour-shop are the avoirdupois for the larger quantities, viz., 16 ounces = 1 lb., and the troy weight for small quantities, viz., 24 grains = 1 dwt. ($437\frac{1}{2}$ grains = 1 oz. avoirdupois.).

Measures.—The vessels for measuring the colour solutions, mordant liquors, etc., are best made of copper, and of the round bowl or ladle shape, so as to allow no corners for harbouring colour or dirt. Copper is found to be the most suitable metal for making colour-shop utensils; as it is little affected by the acids and mordants employed, and always keeps a clean bright surface. When measuring ammonia, however, an earthenware vessel is used, as copper is readily acted on by this reagent. The liquid measures in use may vary from $\frac{1}{16}$ to 1, that is, from the $\frac{1}{16}$ of a gill to 1 gallon of 32 gills. In the manufacturing districts of England the "gill" measures a $\frac{1}{2}$ pint, or 10 fluid ounces, and the "noggin" or $\frac{1}{4}$ pint equals the Scotch gill or 5 fluid ounces. In copying colour-recipes it is well to remember this. The most useful sizes of measures are as follows: $\frac{1}{16}$, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, and 1 gill, 2 gills, 4, 6, 8, 12, 16 gills, or $\frac{1}{2}$ gal., and 1 gallon. All the measures, especially the smaller ones, should be carefully tested and compared with each other before being put into use.

Standard Dye Solutions.—Standard solutions of the colouring matters employed are made at the strength of from $\frac{1}{4}$ to 1 lb. of colour per gallon water, according to the requirements of the colourist. Each colour chemist, as a rule, makes his own choice of dyestuffs, by the proper admixture of which he can match any shade of colour required. This selection of dyestuffs represents to the chemist what the palette is to the artist. A too extensive selection is not advisable, as the employment of too many colour-stuffs not

only requires space for storage, but is liable to confuse the labourers in the colour-shop and give rise to mistakes. From the wide range of colours now at the command of every colourist, he must select those, after careful experiment, which suit best his own particular requirements. The advice given by a high authority on art, "a restricted palette is to be recommended," is applicable to dyers and carpet-colour mixers as well as to artists. The standard dye-solutions are prepared in the copper steam-pans, with careful stirring until all the colouring matter is completely dissolved. A great deal of success in making good colours depends upon the proper methods employed in dissolving the dyes.

GENERAL REMARKS ON TREATMENT OF COLOURS.

Storing.—The colours should be kept in closed tins, or in their casks with their lids on, and in a place which is dry but not too warm. They should never be allowed to remain exposed in a damp, steamy dye-house or colour-shop, where they are liable to get wet or draw moisture; and thus becoming deteriorated in strength and often conglomerating into hard lumps difficult to dissolve.

DISSOLVING ANILINE DYES.

Dissolving Dyes for Standard Solutions.—If the colouring matters have a tendency to crystallise out after the liquid is cooled, the addition of a little thickening agent, such as wheaten flour or gum, gives the liquor sufficient consistency to prevent, in most cases, this recrystallisation. Many dye-solutions have to be re-heated before mixing in the colour paste, in order to dissolve the minute crystals floating through it. Magenta Auramine Diazo Orange of various brands, Rhodamine or Rosazaine, Naphthol Yellow, Patent

Blue, etc., are examples of such dyestuffs. If the precaution of re-heating such solutions when required be not observed, the prepared colours—unless the paste is very hot—will turn out “spotty,” producing stains and colour specks on the yarn, which are often difficult to remedy. In dissolving the dyes for use, a certain amount of care must be exercised. The best way for some dyestuffs is to pour the hot water (160° to 175° Fah.) on the colour-powder, stirring briskly all the time. Other colours, such as the Nigrosines, or Induline class of colours, Methyl Violets, Magenta, several of the Benzaldehyde Greens, if treated in the above way, go immediately into a tarry sticky lump, difficult to dissolve. Such colours are best mixed in cold water first, then gradually, with constant stirring, brought to the required heat in the steam-pan. A hard water is unsuitable for dissolving dyes; as it precipitates the colour base—in such cases a little vinegar is added to correct this (see “Water,” chap. iv.). Over-heating or dissolving direct over a fire is liable to cause insoluble tarry matters to be formed. After the standard dye-solutions are made, they may require to be filtered through calico or flannel to keep back any undissolved particles.

This is of much importance, for if the colour be not properly dissolved, stripes and specks will probably mar the beauty of the printed work. Most aniline colours require filtering, although some of them, *i.e.*, Magenta, Scarlet, Orange, Eosine, etc., are easily soluble.

Dyes like Magenta, Cerise, Crimson, Violet, Alkali Blue, Eosine, Induline, Bismarck Brown, Bordeaux, Scarlets and Oranges, Yellow, China Green, Green Crystals, dissolve best in boiling water in the proportion of 1 to 50.

Colours like Methyl Green, Imperial Green, are best dissolved in lukewarm water (112° Fah.).

Spirit colours are dissolved in the proportion of 1 to 30,

beginning cold and gradually heating the spirit in a water-bath. Keeping it well stirred until the colour is all dissolved.

Water.—The nature of the water used for dissolving aniline dyestuffs is an important consideration. Colours may be blamed for containing tarry matters, when the real cause lies in the water with which they were dissolved. Calcareous waters are injurious to many colours of basic nature, like Malachite, Diamond, and other basic greens, Magenta, Methyl Violets, Victoria and Night Blues, and many others. The calcium and magnesium salts present in hard waters precipitate the colour base as a fine tarry precipitate, which may give the colour, when printed on the yarn, a more or less streaky or spotted appearance. Pure water is best for dissolving such dyes; and this may be obtained from the scouring department, if the condensed water is collected in the manner described under "scouring of yarns," (chap. ii.). If soft water cannot be obtained, hard waters may be corrected, for dyeing and colour-dissolving purposes, by the addition of a little acetic acid, about 1 pint to 100 gallons of water (see chap. iv. regarding the natures of different waters and methods of softening).

CHAPTER VII.

COLOUR-PRINTING PASTES—WHEATEN FLOUR—PASTE-MAKING —STRAINING COLOURS—ACIDITY OF COLOUR PASTES.

WHEATEN FLOUR FOR COLOUR PASTES.

THE thickening medium for tapestry carpet colours is wheaten flour paste, made of a good medium quality of flour, thickened at the rate of about 75 lb. of flour per 100 gallons of water, to which is also added $4\frac{1}{2}$ lb. alum; or if sulphate of alumina is preferred, $3\frac{1}{2}$ lb. Flour paste is made in large quantities at a time, as it serves as the medium for conveying the colours to the carpet yarn. With some colours, the addition of a little British gum is necessary to give them the desired toughness or gumminess, not obtainable with flour alone. Many experiments have been tried to employ starch or farina in place of wheaten flour for colour-mixing pastes; but the colours made by this method are rough and lumpy in nature, and readily become watery. A glutinous flour which boils into a gummy tough paste is the best for making carpet colours, and is to be preferred to a "starchy" flour. The larger the percentage of starch present in a flour, the less it is suitable for making a good smooth colour paste for yarn printing. The following analyses show the difference in composition between a good gummy flour and wheaten starch:—

GOOD WHEATEN FLOUR.				WHEATEN STARCH.	
Water	-	-	-	16.50	15.87
Fatty Matters	-	-	-	1.20	—
Gluten	-	-	-	11.80	—
Starch	-	-	-	66.27	82.81
Mineral and other matters	-	-	-	4.23	1.32
				<hr/> 100.00	<hr/> 100.00

The presence of *bran* in wheaten flours is an objection, as it makes a paste wanting in stability. The bran readily causes fermentation, which makes the paste, after standing, become thin and readily decomposed.

Paste for Printing Carpet Yarns.—As a good colour paste is all-important in carpet colour-mixing, the following hints on the best way of making a proper paste may be found useful. In making a paste of good smooth quality, care must be taken not to boil it for any time, or let its temperature rise as high as 200° Fah. Over-boiling makes a lumpy paste, curdled and rough in its consistency, which does not mix so readily with the various colour ingredients. After such a paste is strained through the wire sieve, the minute granules of starchy matter are still present, and may appear on the printed yarn as white spots. In making paste it is best not to heat it higher than 186° to 185° Fah. (82° to 85° Cent.). This is attended to by the paste maker who is provided with a thermometer for the purpose. The following quantities are for making a batch of 300 gallons:—

Into the paste tub, half filled with water, is stirred—

225 lb. Wheaten flour.
13½ „ Alum, or 10 lb. sulphate of alumina.

The doughy lumps of flour floating on the surface are all carefully broken between the hands. Steam is then blown into the liquid by means of a copper pipe, or worm, perforated with holes. During heating, the milky liquid must be in constant motion to keep the flour particles in suspen-

sion. If allowed to settle down to the bottom of the tub, a bad batch of paste is the inevitable result. The stirring is done either with hand-sticks or by mechanical stirrers. The heating is continued until the temperature reaches from 180° to 185° Fah., when steam is shut off, the copper boiling pipe removed, and the paste allowed to stand undisturbed for five or seven minutes. This is found to be an advantage, as it develops the strength of the flour better. The paste, during the heating with open steam, has gained a considerable quantity of water by condensation; more water is now added with constant stirring until the containing mark of the tub is reached, viz., 300 gallons. If the above be made with a suitable flour, it will make a good quality of paste. It requires an occasional stir up to prevent it turning rough or starchy. An antiseptic, such as carbolic acid, $C_6H_5(OH)$, may be added during the warm months to keep the colour-pastes from decomposing. When paste is boiled and allowed to stand overnight, a thick tough skin, like leather, forms on the top. This must not be stirred in, but skinned off. The formation of skin is easily prevented by covering the surface of the paste, or boiled standard colour, with a little water at night, when in the morning it will be found soft, and without any indication of toughness.

• *Straining Colours.*—Colours for tapestry carpet printing must be smooth and free from any knots of paste or colouring matter; and in order to attain this, all colour-pastes must be strained previous to their being made into colours for printing. Colour-strainers are made in the form of rectangular wooden boxes of 1-inch wood, six inches in depth, with a bottom of wire gauze, either of brass or copper. Copper wire gauze is better as it lasts longer, and is not so easily acted on by the acid mordants. The gauze is generally of two degrees of fineness, one quality with 169 meshes to the square inch, used for straining paste and thickened colours.

The other quality is much finer, with 1024 meshes per square inch, and used for the thinner dye liquors. Where a finer sieve is necessary, as for straining standard dye solutions, flannel or calico can be used. A useful size of sieve for small work is ten inches square inside, by six inches deep. For large tubs, or straining large quantities at a time, three feet square by ten or twelve inches deep is a good size. A suitable number of strainers are needed in the colour-shop, as it is necessary to keep one for each class of colours.

Acidity of Colour Pastes.—In the printing of tapestry carpet yarns only a limited number of mordants can be employed. Adjective colouring matters, or those which can only be dyed with the assistance of basic mordants, the anthracene group, for example, with the alizarines, some of the Phthaleins and Resorcines like Gallein, Cærulein, Gambine, Resorcin Green, etc., though of much value to the dyer, are of little service to the tapestry colour-mixer. The shades obtained from them by printing and steaming are of poor quality; wanting in richness and depth. Although many experiments have been tried to introduce this class of dyes into tapestry carpet printing, the results have never proved very satisfactory. All colour-pastes for tapestry printing must have a certain degree of acidity, to fix and fully develop the colouring matters on the wool fibre during the steaming process. The presence of an insufficient amount of acid renders the colours poor and uneven; while an excess of acid tends to corrode and tender the wool. (See effect of excess of mordant in illustration of wool fibres under steaming.) Much success depends upon the proper degree of acidity employed in developing the colours. For many years tartaric acid ($C_4H_6O_6$) has been used as the most suitable mordant for this purpose, as it possesses strong acid properties, and has no injurious effect on the wool fibre. The strength of acid used is generally about 6·3 gram per litre, or nearly one ounce (avoir.) per gallon

of colour paste. This acidity is sufficient, in most cases, to fully develop and fix the colours. Owing to the high price of tartaric acid, and also citric acid ($C_6H_8O_7$, H_2O), which is similar in nature, many substitutes have appeared on the market under various names, all of which could no doubt be prepared with less expense by the consumers themselves. (See *Tartar Substitutes* in Glossary of Drugs at the end.)

Other acids, viz., sulphuric, oxalic and acetic acids, have been employed for giving the necessary acidity to the colour pastes; and recently lactic acid ($C_3H_5O_3$) has been shown by the present writer to possess interesting properties to the carpet yarn printer.¹ The various qualities necessary for a successful colour printing paste for carpet yarns will be specially considered in our next chapter.

¹ Vide, *Dyes and Calico Printer*, Sept.-Oct., 1897.

CHAPTER VIII.

QUALITIES NECESSARY FOR WOOL YARN PRINTING COLOURS
—ACIDITY—LEVELLING AGENTS—ALUMINA MORDANTS
—COLOUR RECIPES FOR YARN PRINTING.

THE mordants employed in printing tapestry yarns are not so numerous as those used in the kindred art of Dyeing. The interesting class of polygenetic colouring principles, the Alizarines, Anthracenes, Gallein, Dioxine, etc., and their varied mordants, so valuable to the dyer, are of little service in this branch of textile printing. The results obtained with them are far from being satisfactory. Wool which has been previously mordanted, when dyed in a bath with such colouring matters, gives rich and fully-developed shades. If, however, the colouring principle and mordant be mixed together in the colour-paste, as in the making of tapestry colours, and the resultant mixture be printed on the yarn and steamed, the colours produced are poor and uneven, not to be compared for richness of shade to those obtained by dyeing with the same colours and mordant. Perhaps, after further experimental inquiry has been made into the causes of such irregularities, and the action of basic mordants during the operation of steaming, some improved process may yet be introduced which will enable the yarn printing colour chemist to employ this valuable group of colouring matters. At the present time the unsatisfactory results given with all the adjective colours exclude them and their mordants from tapestry yarn printing. Since the introduction of the aniline colours, the work of the dyer and "colour mixer" has been much simplified. The preparing

of the colours, instead of being a long and tedious process, requiring many mordants and colour ingredients, has now become a comparatively easy operation. The old "rule of thumb" or empiric methods, where the real art was jealously shrouded with mystery in a complexity of drugs and meaningless names, are now things of the past. The elements necessary to ensure a well mordanted tapestry printing colour are threefold, namely:—

1. Acid properties—non-injurious to the wool fibre;
2. A levelling agent;
3. An alumina base.

The above qualifications do not refer to special cases where colours require certain particular mordants. Such examples will be found spoken of separately under their respective mordants in the subjoined list. These three necessary qualifications for a proper tapestry printing mordant will now be briefly considered.

1. *Acid Properties.*—In tapestry printing it is most essential to make the colour-paste decidedly acid, so that the colours may be properly fixed and developed upon the yarn. Without the presence of acid, the printed colours are wanting in fastness and quality of tone, and show signs of being "stripy" or uneven. In choosing an acid for this purpose, special attention must be given to its general effects upon the wool fibre and the appearance of the various colouring matters. An acid which is beneficial to one class of colours may also be injurious to another class of a different nature. The acid mordant must not have a corroding action on the wool; such a quality would become highly injurious in the steaming operation. The most useful acid for wool printing has been proved, after long experience, to be tartaric acid ($C_4H_6O_6$). Its strongly acid properties, combined with a non-injurious effect on the wool fibre, and its power of developing colours to the best advantage,

render it of great value to the tapestry colour chemist. Owing to its comparatively high price many so-called "substitutes" have been introduced, composed mainly of sulphuric or oxalic acids, combined with sulphates of soda or potash. (See tartaric "substitutes" in Glossary of Drugs at chap. xvii.) Volatile acids like nitric or hydrochloric are objectionable, as they become volatilised during the steaming, and in this state act injuriously upon the iron of the steam chests. For this reason vinegar should not be employed in every colour; but only in a few special cases where it is required. (See acetic acid.) The best degree of acidity for printing pastes is at the rate of one ounce (avoir.) pure tartaric acid per gallon of colour, or 6·3 grams per litre. This acidity is found to be sufficient to fix and develop the colours on the yarn. Instead of tartaric acid, a mixture of sulphuric and oxalic acids may be used, which forms a useful and inexpensive acid mordant. For the different degrees of acidity or neutralising power, it is found that ten parts tartaric acid equal eight oxalic or six sulphuric acid.

2. A "*levelling*" *Agent*.—Such an agent is as necessary in printing as in dyeing, to make the colours "take on" evenly and prevent any blotches or striped appearance. Glauber's salts or sulphate of soda, sulphate of potash, alum, sulphate of alumina and lactic acid are useful for this purpose.

3. An "*Alumina Base*".—In all tapestry colours—except where iron and tin mordants are used—alumina requires to be present. It forms one of the most useful mordants to the yarn colour mixer, as it develops and levels the colours on the yarn in a way not easily obtainable with any other mordant. The alums and sulphate of alumina are extensively used for mixing in the colour-pastes in quantities varying from 3 to 6 oz. per gallon, according to the nature and requirements of the colour.

As these three qualifications, *i.e.*, (A) acidity, (B) levelling agent, (C) alumina base, are important in making a successful yarn-printing colour, they will now be treated individually.

A. Acidity required in Wool Printing.—What is most essential in a mordant for ordinary yarn printing is a good strong acid reaction; not too strong to tender or corrode the fibre, but just sufficient to fix and develop the colours on the wool during the steaming process. Tartaric acid, as already stated, has long been employed by wool printers as an ideal mordant in this respect. It possesses the necessary strong acid reaction, combined with a non-injurious effect on the wool fibre, unlike some of the stronger mineral acids. The best degree of acidity to employ for carpet yarn printing is considered about 6·3 grams tartaric per litre of printing colour; or 28·34 grams per 4½ litres, which equals in British measure 1 oz. tartaric per gallon of paste. With this acidity colours are fixed and developed sufficiently well on the fibre, but in some special cases the colour may require a little more. It will be noticed that the acid required for carpet yarn printing is small compared with that used in woollen cloth printing, where 3 to 6 oz. tartaric per gallon paste are generally used. The commonly employed acids beside tartaric are sulphuric, oxalic, acetic acid, and also lactic acid, which may be used with advantage. The following proportions by weight of acids will be found to correspond as nearly as possible to each other in point of acidity:—

Acids.	Grams.	Or in Ounces (avoir.).
Tartaric - - - - - ($C_4H_6O_6$)	28·34	1 oz. drams.
Oxalic - - - - - ($C_2H_2O_4$)	22·67	- - 12½
Sulphuric (strong) - - - (H_2SO_4)	17·0	- - 9½
Lactic acid (50 per cent.) ($C_3H_5O_3$)	70·85	2½ oz.

The above are the relative weights of acids required per gallon (4½ litres) to form printing pastes of equal acidity.

It will be seen that 1 oz. tartaric or 28·34 grams has the same degree of acidity as 22·67 grams oxalic or 70·85 lactic acids. In studying the action of the various acids as mordants it is necessary to note its effect on the colours, and also on the fibre of the wool. Acids which impair the softness or lustre of the fibre must be discarded.

Azo or Acid Colours.—As most of the colours of this group require a strong acid reaction to fix them on the wool, the addition of sulphuric or oxalic acids is necessary. It is readily found by experiment what acid is specially suitable for the dyestuff; as certain colours are better developed with sulphuric acid than with oxalic, lactic or acetic acids, and also the *vice versa*. The following table, giving the results of the various acid mordants with the azo colouring matters, is based on the writer's own experiments.

EFFECT OF ACID MORDANTS.

Name of Colours	Sulphuric Acid	Tartaric Acid.	Oxalic Acid	Lactic Acid.
Rocellines, Fast Reds, Cloth Reds, etc.	slight tendency to unevenness.	good colour	slight unevenness of colour.	good colour.
Azo Pinks.	scarcely so rich a colour as with Tartaric and Lactic	good level colour.	similar to Tartaric.	good colour, level and richer than any other.
Azo Scarlet (various brands).	beautifully rich colour.	slightly yellower hue than with Sulphuric.	similar to Sulphuric colour.	yellower colour, similar to Tartaric.
Acid Magenta	richest and fullest colour	very good colour.	very good colour, better than Tartaric.	not fully developed, inferior colour.
Oxy-azo Oranges (various brands).	very good colour, fully developed.	same as Sulphuric.	same as Sulphuric.	same as Sulphuric.
Aniline Yellows (various).	good rich. Long	good rich colour.	much poorer, thin and weak colour.	good rich colour.
Acid Greens, Blues, and Violets.	all shades level and rich.	similar to Sulphuric.	similar to Sulphuric.	similar to Sulphuric.
Acid Blacks, Naphthol, Brilliant, etc	apt to give bluish Blacks.	rich full Black.	somewhat bluish Blacks, not so much, however, as Sulphuric.	rich full shades.

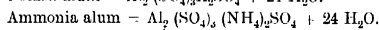
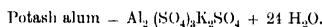
Basic Colours.—With colour stuffs of this nature, such as Magenta, Malachite Green, Methyl Violet, etc., which have a strong natural affinity for wool, the addition of acid to the printing paste shows little, if any, development of the colour. Such dyestuffs have of themselves, sufficient affinity for the wool without the assistance of acid. The presence of acid in wool yarn printing is, however, always necessary to ensure level and satisfactory colours. With the benzidine or diamine colours, no advantage in the use of acid is noticed.

B. What are termed "levelling agents" in yarn printing are substances, usually the normal salts of potash and soda, which are added to the printing paste to make the colours dye evenly on the fibre in the steaming. Without the assistance of such levellers the colours in many cases go on unevenly and cause stripey and blotched work in the finished carpet. The action of such an agent in steaming is no doubt similar to that in dyeing; namely, of making the dye-stuff go slowly on to the fibre and thus preventing unevenness of colour. Glauber's salts (sulphate of soda), potash, alum, sulphate of potash or ammonia, lactic acid, phosphate and acetate of soda, are found to be useful levelling agents.

C. *Alumina Mordant.*—It is customary to add to every colour for yarn printing a certain proportion of a salt of alumina, either alum or aluminium sulphate. This is always done except where salts of iron (nitrate or sulphate), or of tin (tin crystals) are already present. In such cases alumina cannot be employed, otherwise it would destroy the action of those metallic mordants. Alum develops and fixes the steamed colours on the wool in a way that no other mordant does; and is used in quantities varying from 3 to 6 ounces per gallon of colour paste.

Alum.—The salts of alumina are of much interest to the carpet colour mixer, as they form his most important mordant. All colour pastes must have a certain amount of

alumina (Al_2O_3) in their composition, either in the form of alum or sulphate of alumina, to develop the colours fully and fix them on the yarn during the steaming process. Without the addition of aluminium salts to the printing paste, the great majority of the colours are imperfectly fixed, and appear uneven or "stripey". The alums are the crystallised double salts of sulphate of alumina and potash, soda, or ammonia, thus:—



Potash alum contains 10 per cent. alumina (Al_2O_3), while the ammonia, or what is termed "Roman" alum, contains 11 per cent. This alum is easily recognised by the pungent smell of ammonia, which is liberated on heating a little of it with dilute caustic soda.

The following analyses of these alums show the different proportions of their constituents:—

PERCENTAGE COMPOSITION OF ALUMS.

	Potash Alum.	Ammonia Alum
(Al_2O_3) Alumina - - - - -	10.83	11.84
Sulphuric acid - - - - -	33.71	35.29
Water - - - - -	45.51	49.62
Potash - - - - -	9.95	—
Ammonia - - - - -	—	3.75
100.00	100.00	100.00

Instead of the alums or double salts of alumina, the normal sulphate of alumina (*q.v.*) is now much used in dyeing and yarn printing, as it contains a much larger percentage (15 to 18) of the valuable constituent *alumina*. There is little doubt but the sulphates of potash and ammonia present in alums help to make the printed colours take on more evenly, and thus play the part of "levelling" agents. In carpet

printing colours of the ordinary class require about 3 oz. (avoir.) alum per gallon of colour paste. With stronger shades, or those containing a greater amount of colouring matter, a larger quantity of alum is necessary, even as much as 6 oz. per gallon. Fustic and many other vegetable colours are greatly developed with alumina mordants, giving them a purity of tone unattainable with any other mordant. The presence of iron salts in alums must be guarded against, as many colours, especially the wood dyes, can never be bright and up to their true quality of tone where this impurity is present. As the iron may be either in the ferrous or the ferric state, the most suitable reagent for showing its presence is a solution of ferro-ferric cyanide of potassium; a few drops of which added to a solution of the alum will show an immediate blue coloration on any trace of iron being present. The black colour produced with tannic acid, tincture of galls, or logwood also readily shows iron.

Aluminium Sulphate.—*Patent Alum, Sulphate of Alumina, Concentrated Alum, &c.* This normal salt $\text{Al}_2(\text{SO}_4)_3 + 18\text{H}_2\text{O}$ is now being largely used in place of alum, as it contains a larger percentage of the valuable constituent alumina (Al_2O_3), and is more economical for preparing the various aluminium mordants. Until recently the alums were preferred to sulphate of alumina, as they are of a definite and unchanging chemical composition, regular in the percentage of alumina and sulphuric they contain, and less liable to have iron as an impurity. Formerly these valuable qualities were not always found in sulphate of alumina, but now, owing to improved methods of manufacture, a sulphate of alumina of pure quality and regular composition has become an article of commerce. The normal salt contains 15 per cent. soluble alumina, and more concentrated qualities are to be met with in commerce, showing from 17 to 18 per cent. soluble alumina. It may accordingly be found of two

strengths, viz., 15 to 16 per cent., and 17 to 18 per cent.; these figures representing the amount of soluble alumina present. The following is an analysis of a commercial sulphate of alumina, which shows the high degree of purity in which this salt can now be obtained:—

COMMERCIAL SULPHATE OF ALUMINA.

Soluble alumina (Al_2O_3)	14.90
Combined Sulphuric Acid	34.79
Free Sulphuric Acid	none
Water of Crystallisation	49.73
Insoluble matters58
	<hr/>
	100.00

Sulphate of alumina is readily soluble in water, giving a clear heavy solution at 4 to 8 lb. per gallon of water, and showing little tendency to crystallise. This is a useful property to the colour chemist, as the salt may be kept ready dissolved for a mordanting liquid, without fear of its becoming altered in strength by crystallisation. In substituting sulphate of alumina for alum in colour recipes, a less amount is required according to the percentage of alumina present in the sulphate used. Thus,

<i>Sulphate of Alumina</i>	<i>Crystal Alum.</i>
7 parts of 15 per cent., or	} equal 10 parts.
6 parts of 17 per cent.	

The question of how sulphate of alumina acts as a printing mordant in its relations with the varied natures of the colours, the quality of shades produced, and their evenness of tone in comparison with the colours made with the double salts or alums, yet requires to be investigated. The sulphates of potash or ammonia present in the alums no doubt help to fix the colours on the yarn, and act as "levelling agents" as in dyeing.

COLOUR RECIPES.

Yarn Printing Colour Recipes.—The following colour recipes may be taken as typical examples of yarn printing colours. Where acetic acid is employed, it can be replaced by a suitable proportion of sulphuric or tartaric acids.

RED.—Dissolve

40 parts by weight of Roccelline. Fast red, wool scarlets (or any of the reds mentioned in chap. xvi.), in			
210	"	"	hot water. Then add
675	"	"	flour paste *
75	"	"	vinegar 11° Tw., or a suitable proportion of vitriol or tartaric acids.
1000 parts.			

After printing, steam for $\frac{1}{2}$ to 1 hour with gentle pressure, then wash.

ORANGE.—Dissolve

5 parts by weight of orange (i. (or any of azo oranges) in			
245	"	"	hot water. Mix with
650	"	"	good thick paste *
100	"	"	vinegar 11° Tw., or suitable proportion of vitriol, tartaric, or oxalic.
1000 parts.			

Another method recommended for acid colours is as follows:—

Per Gallon of Colour	—	Per Litre of Colour.
5 oz.	or	30 grains colour powder dissolved in
2 pints,	"	200 grains hot water, and stir into
8 lb.	"	770 " flour paste *
25 drops reduced sulphuric acid 1 : 10	"	25 drops sulphuric acid reduced 1 : 10
		1000 grains.

*For acid dyestuffs alumina, either in shape of alum or sulphate of alumina, requires to be present in the flour paste.

A BLACK, suitable for yarn printing is made as follows :—

Dissolve

75	parts by weight of Naphtol, or brilliant blacks, in
200	" " " " hot water. Add
7.5	" " " " thioearmine paste,
600	" " " " thick paste,
15	" " " " chlorate of soda,
12.5	" " " " alum,
15	" " " " sulphuric acid at 170° Tw. mixed with
75	" " " " water.

1000 parts.

CLARET.—Dissolve

75	parts by weight of Amaranth or Grenadine in
200	" " " " hot water. Mix with
625	" " " " paste,
100	" " " " acetic acid, 11° Tw.

1000 parts.

BLUE.—Dissolve

30	parts by weight of Janacyl, Victoria, or any of the
	alkali Blues in
200	" " " " hot water. Mix with
650	" " " " paste,
10	" " " " chlorate of soda,
100	" " " " acetic acid 11° Tw.

1000 parts.

YELLOW.—Dissolve

30	parts by weight of Naphtol, Fast, or acid yellows, in
100	" " " " water (hot),
810	" " " " paste * (containing gum as well as flour),
60	" " " " vinegar 11° Tw.

1000 parts.

GREEN.—Dissolve

40	parts by weight of any of the aniline greens, (chap. xvi.), in
195	" " " " hot water. Mix with
675	" " " " paste,*
90	" " " " vinegar 11° Tw.

1000 parts.

* (See footnote, page 57.)

The printing recipe recommended for the benzidine or diamine colours may be given as follows:—

Per Gallon	or	Per Litre.
7 oz.	„	40 grams diamine dyestuffs dissolved in
2 pints	„	190 „ hot water. Mix in
8 lb.	„	770 „ flour paste.
		<hr/> 1000

For diamine colours as above, it is unnecessary to add alumina mordant or acid, because these colouring matters, as a rule, print level and full shades without addition of mordants.

All other shades, produced by the admixture of two or more dyestuffs, are made on the same principle as those we have already given.

After printing, the yarns are steamed at low pressure for $\frac{1}{2}$ to 1 hour (see chap. xiv.).

CHAPTER IX.

THE SCIENCE OF COLOUR MIXING—EXAMPLES SHOWING THE TRUE CAUSES OF THE FORMATION OF GREEN—BLACK—MOSS GREEN—COMPOSITE BLUE, AND VIOLET COLOURS.

The Science of Colour Mixing.—Before leaving the colour-making department, and proceeding to describe the mechanical operation of printing, we will treat briefly the philosophy which underlies the art of mixing and matching tapestry colours. Much success depends upon the proper method of making the printing colours, and a thorough practical experience in the business is necessary before satisfactory results can be established. It will be found that a knowledge of the chemical and optical properties of the dyestuffs employed is of much service in guiding the colour chemist in his experiments; and in the proper method of making his various shades. The simple primary and secondary colours are easily prepared direct from the many beautiful aniline colours now in use. It is in the making and matching of the innumerable tertiary or compound shades, buffs, sages, drabs, with all their varieties of hue, that difficulty is experienced. With all such colours, several colour ingredients are generally necessary, and great care must be exercised in catching the exact effect, as the slightest excess of either of the dye-constituents causes the colour to lose its desired cast. Some shades of this class, it will be noticed later on, are very sensitive to different qualities of daylight; a dull hazy day, the light from the setting sun, or that from a cloudless blue sky, affect their

appearance considerably. (See chap. x.) As it is by the process of mixing colours that the great diversity of hues used in the textile arts are obtainable, the principles underlying the art or colour mixing should therefore be of the greatest interest to every dyer and colour chemist. It is one of the first duties, in testing a colouring matter, to examine what is termed its mixing qualities, *i.e.*, its capability of producing good and useful shades by admixture with others. Mere naked-eye examination of a dyed colour cannot show whether it will be suitable or not for producing good mixed shades. Two colours may closely resemble each other in hue, when dyed separately, but if each be mixed in exactly the same proportion with another colouring matter, the results may be totally different in appearance. Two Blues, for example, may match each other perfectly when dyed separately on the yarn, but if each be mixed with a certain proportion of yellow, the greens obtained may be of a very different nature; one may be a bluish-green, while the other may approach more to the olive cast. Many instances might be given of dyestuffs, apparently similar in hue, which produce unexpected results on admixture with other colours. Again, two colours may also match closely in daylight, but when viewed in gaslight, may appear totally different from each other. Anomalies like these are naturally perplexing to every colourist, but the explanation of all such apparently erratic behaviour will be found in the spectroscopic examination of the colouring matters themselves. Many dyers and colour mixers have a good "rule of thumb" idea regarding the mixing of colours, but such empirical knowledge is not only unsafe, but is learned often at the expense of many failures and disappointments, which might have been avoided with the aid of a little science. A few examples showing the philosophy of colour mixing will now be briefly studied:—

Example I.—It is well known that Indigo Extract and Naphthol Yellow when mixed yield a green. This green is produced, not because the Indigo only allows the blue rays to pass and the other only the yellow rays, but because both of them, when combined, absorb nearly all the colours of the spectrum except the green, which is allowed to pass freely. This may be more clearly illustrated in Fig. 3, which represents the absorption spectra of these two colouring

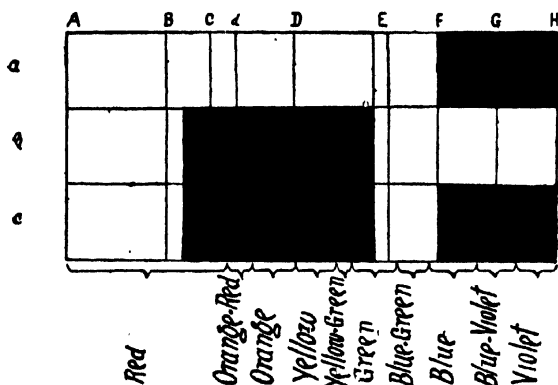


FIG. 3.

Example II.—Green produced with (a) Naphthol Yellow and (b) Indigo Extract.

matters. The lines marked A, B, C, D, etc., indicate the well-known Fraunhofer lines in the solar spectrum.

(a) represents the absorption spectrum of Naphthol Yellow, which shows that this dye absorbs the violet, blue-violet, and blue, and freely transmits the remainder of the spectrum, green, yellow, and red.

(b) represents the absorption spectrum of Indigo Extract, which shows free transmission of the extreme red, and

absorption of the orange red, yellow, and yellow green, to the lines E in green, and transmission of green, blue, and violet.

(c) represents the spectrum of the green colour produced by combining (a) and (b), viz. : Naphthol Yellow and Indigo Extract. It shows only the blue, bluish-green, green, and a portion of red to be transmitted. A green colour showing an absorption spectrum like (c) cannot be a pure bright colour, from the amount of red it contains. If, instead of Indigo Extract, a greenish blue, showing absorption in the red, were substituted, a pure and bright tone of green would be obtained.

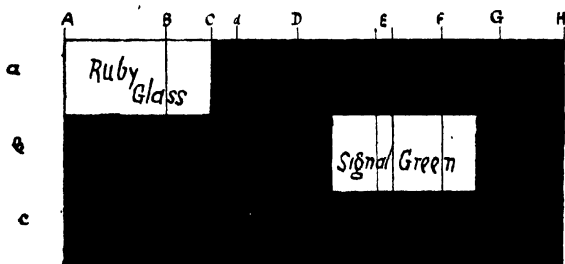


FIG. 4.

Example II.—Showing how Red and Green produce Black.

Example II.—A mixture of red and green, when sufficiently strong, will produce a black. All the coloured rays transmitted by the one are absorbed by the other; hence darkness or black is the result. It is seldom that two complementary dyes are found of sufficient purity to produce a pure black, but with three colours a good dense black can easily be obtained. This fact is taken advantage of in dyeing and colour mixing when jet black is required; and also in pro-

ducing sad shades, *i.e.*, colours darkened or saddened with a more or less proportion of grey, produced by complementary colours coming in contact. A splendid, though somewhat expensive, black for tapestry carpet printing can be made by combining Archil with indigo extract. These two are complementaries to each other. The following absorption diagram will show this clearly. Fig. 4 represents the absorption bands of ruby glass (*a*) and signal green glass (*b*), which when superposed produce black or total extinction of light (*c*).

(*a*) This spectrum shows free transmission of red from A to orange red in C, with total absorption of all other colours.

(*b*) Shows absorption of all the spectrum except yellow green ($D\frac{1}{2}$ E), green, and blue, to the blue violet ($F\frac{1}{2}$ G).

(*c*) It will be seen that when two such colours are mixed, no coloured ray is allowed to pass, hence darkness or a black is the result.

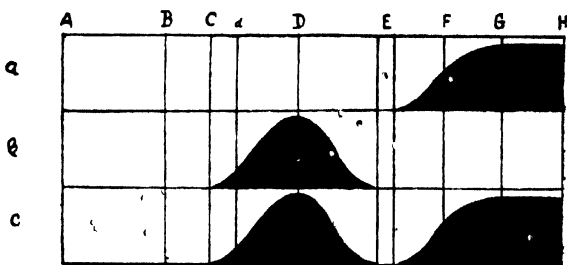


FIG. 5.

Example III.—A Moss-green shade produced by combination of Naphthol Yellow (A) and Methyl Violet (B).

Example III.—If the moss-green shades produced by the admixture of Naphthol Yellow and Methyl Violet be analysed, it will be found that their colour is produced not simply by

the combination of the blue and red of the violet with the yellow, but because green and a little red, which constitutes a soft moss green, are the only coloured rays allowed to pass unabsorbed after violet and yellow are mixed. The Naphthol Yellow absorbs all the violet, blue, and blue-green light, and transmits freely the green, yellow, and red; while the Methyl Violet (see *b*, Fig. 5), absorbs yellow and yellow green, and allows red, green, blue, and violet rays to pass freely. The nature of such a class of shades can be better understood by studying the absorption spectra of the component colours (Fig. 5). The black curves represent the locality and degree of colour absorption.

(a) Is the absorption spectrum of Naphthol Yellow.

(b) Methyl Violet 3B showing strongest absorption in the yellow and yellow green.

(c) Spectrum of the compound moss-green shade, showing transmission of red and green rays, with absorption of the other parts of the spectrum.

Example IV.—The formation of the beautiful class of composite blues known as indigo substitutes, by mixing a green with a violet can be explained in the same manner. By examining such blues with the spectroscope, it will be found that the brightest part of the spectrum, *i.e.*, orange red, orange yellow, and yellow green is more or less absorbed, while the green and blue are freely transmitted, giving to the mixture its blue appearance. The benzaldehyde greens like Malachite and Victoria Green show strongest absorption in a portion of the red, orange, and yellow; while Methyl Violet absorbs orange, yellow, and yellow green. Thus it will be seen that when the two are combined, the predominating colours transmitted are green, blue green, and blue, with a portion of the red (see Fig. 6). If a purer green be employed, showing total absorption in the red, a brighter and purer tone of blue will be obtained by admixture with

violet. The following absorption diagram shows the formation of this class of composite blues.

(a) The strong absorption in the orange red at C, and towards the violet end of spectrum G to H, is that of China Green (similar to Malachite Green).

(b) Methyl Violet 3B, showing strongest absorption band at D, in yellow.

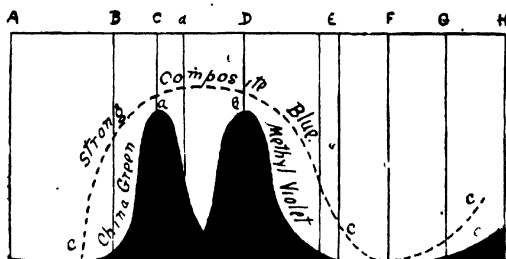


FIG. 6.

Example IV.—Showing the formation of a Blue colour by admixture of Green and Violet.

(c) The dotted line is the absorption curve of a deep shade of composite blue, showing transmission only of the extreme red, green, and blue.

Example V.—A beautiful reddish violet, resembling in hue the famous Tyrian Purple is obtained by mixing green with the pink colouring matter, Rhodamine. The formation of this colour affords a good example to the spectroscopist, as the absorption bands are sharp and characteristic. Rhodamine, being a clear pink dye of great brilliancy, absorbs the yellow green, green, and blue green, and transmits the red orange, yellow, blue, and violet. Most of the basic aniline greens, as we have seen in Fig. 6, transmit a portion of extreme red along with the green, blue green, and blue.

After these two colours are mixed the only light transmitted is red, blue green, and blue, which constitutes the Tyrian purple hue (see *c*, Fig. 7).

- (a) Absorption spectrum of Rhodamine.
- (b) Basic Aniline Green (China Green).
- (c) Spectrum of purple composed of *a* and *b*.

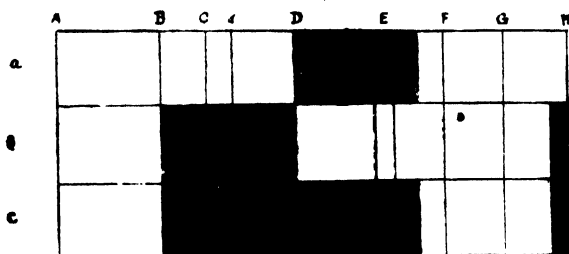


FIG. 7.

Example V.—Showing formation of a Violet colour by mixing Rhodamine Pink (A) with Green (B).

Matching Dyed and Printed Yarns.—The colour pastes, after being prepared and mixed in the colour-house, are printed, or what is termed swatched on small skeins of yarn as trials, and after going through the regular process of steaming, washing, and drying, these swatches are submitted to the colour mixer, who compares or matches them with the standard specimens preserved in the colour-book. The matching of the prepared shades is one of the most important duties of the tapestry colour chemist, and often it requires no little care to obtain a perfect match with some shades. The quality of the daylight used must be considered, as the appearance of many colours is greatly influenced by the kind of light which illumines them. This will be considered in our next chapter.

CHAPTER X.

THE MATCHING OF COLOURS.

GOOD LIGHT—DIRECT SUNLIGHT—BLUE SKYLIGHT—DIFFUSED
LIGHT—ARTIFICIAL LIGHT—DICHROISM—BRIGHT COLOURS
—SPECTROSCOPE.

NOW-A-DAYS, when competition in all branches of industry runs so high, and when prices are so keenly cut, it requires every endeavour on the part of the manufacturer to keep abreast of, and, if possible, to excel his rival. In every business much success depends upon attention to the minutest details, and the manufacturer of coloured textile fabrics must pay due heed to many little, but nevertheless important, considerations in regard to the careful matching and the beauty of his colours. One of the essential qualifications of a good colour mixer is to be able to match accurately any shade submitted to him. In order to do this successfully he must be thoroughly acquainted with the nature and properties of the colours with which he works. We do not intend, in the present chapter, to enter into the practical methods of colour analysis, but merely to give a few useful hints regarding the matching of shades and some details which often require attention.

Importance of a Good Light.—In the matching and comparing of colours, it is of the utmost importance to give special attention to the quality of the daylight which is used. To the majority of people the colour of daylight always appears uniform; but to those whose duty it is to

examine colours carefully, such as artists, dyers and all colourmen, it is well known that the appearance of colours is greatly influenced by the quality of the daylight which illumines them. So uncertain, indeed, is daylight in its hue, that, for the actual colour measurements employed in scientific research, it has to be altogether discarded, and the more stable light of the electric arc substituted. In judging nice distinctions of shade, it is of course necessary that the observer be possessed of good colour perception. There are many people, not in the least colour blind, who cannot see much distinction between two shades, where a skilful eye can distinguish two or three intermediate ones.

Pure Daylight.—The chosen standard of a good white daylight is diffused light of about the month of May, and from a northerly direction. Diffused daylight under these conditions possesses that degree of purity and whiteness necessary to show colours in their truest aspect. The light reflected from a white sky, or from a bank of white cloud, or that quality of light transmitted through a certain degree of mist, are all of a good whiteness and suited for colour examination.

Direct Sunlight.—Direct sunlight is never good for examining colours, as the predominance of red and orange rays renders it unsuitable for seeing many colours properly, especially those belonging to the blue and violet class. Reds, orange and yellows, when illumined by direct sunshine, appear brighter and clearer; while the blues, indigos and the violets lose their blueness of tone and become duller and redder. For this reason the beautiful shades of blue-pinks, heliotropes, light violets, carmines and all such colours, having a small quantity of blue in their composition, cannot be properly examined in the direct rays of the sun. This excess of red and orange rays in direct sunlight is owing to the "interference" or separation of those coloured rays in

passing through the atmosphere. Daylight during a dense fog, or when the sun is near to setting, is also very rich in red rays. This can easily be imagined from the warm tone with which everything is illumined and the fiery-red appearance of the sun at such times. It has been found that the effect on colours, when viewed in direct sunlight late in a summer afternoon, is very similar to coal gas or candle light. The change in the aspect of colours, when viewed in direct sunlight, might be given as follows:—

Reds become brighter and clearer.

Oranges become brighter, more like yellows.

Yellows become brighter and seem to fade.

Greens become bright and clear, if of a yellow cast.

Blues become darker; reddish blues redden in tone.

Violets become redder and approach to purples.

Various beautiful compound shades, or what are often termed mode colours, like drabs, grays, sages, buffs, olives, russets, etc., alter more or less according to the amount of blue they have in their composition. Many little peculiarities in tone, which might escape detection in pure daylight, become apparent in a yellow or orange-tinted illumination like direct sunlight or gaslight. Artificial light is of great assistance to the colour chemist when distinguishing nice differences of cast among greens, blues and violets; but this will be considered more fully further on in this chapter.

Blue Sky-light.—The light reflected from the open blue sky has an excess of blue and violet rays, and therefore produces an effect on the aspect of colours quite opposite from that of transmitted sunlight. It has the tendency of enriching blue and violet colours, and flattening the colours belonging to the red end of the spectrum. Many beautiful pinks, such as the Hosières, rose, Bengal, phloxines, etc., all appear to advantage in such a light, as their characteristic beauty consists of their bluish hue. The fine greenish tones of lemon yellow, auramine, naphthol yellow, etc., are best

seen in a bluish-tinted light ; but when examined in direct sunlight their characteristic beauty disappears. During the summer evenings, and after the sun has set, the light consists solely of reflected light, and is generally of a very blue quality, so blue indeed that red and orange colours appear quite dark, almost blacks ; while red blues and violets lose their red and become much bluer. This explains the reason why a soldier's red coat or a red rose appears black in the dusk. The change in the appearance of colours when examined in daylight coming from a clear blue sky might be given as follows:—

Reds become duller and flatter in hue.
 Oranges become duller and flatter in hue.
 Yellows become somewhat greener in hue.
 Greens become a little bluer and not so yellow.
 Blue greens become bluer.
 Blues become richer and of a purer tone.
 Blue violets become like blues.
 Violets become more blue and lose red cast.

The predominating tints from direct sunshine, or from a blue sky, present in common daylight, explains why colours are seen to alter so much in appearance when viewed first in a bluish skylight, and then in the direct rays of the sun. The contrast between the two qualities of light becomes at once apparent, as each shows the slight predominance of an opposite colour. This effect is clearly seen in viewing natural objects illuminated with direct sunlight ; while their shadows are lit only by reflected light. The object itself appears ruddier or warmer in tone, while the shadows are of a bluish or violet hue. From what has just been stated, it will be clearly seen that the selection of a light for colour examination is a question of great importance to every colourist.

Diffused Daylight.—If transmitted sunlight, with its predominance of red and orange rays, and the reflected light of

the blue sky, with its excess of blue and violet rays, be mixed together, the result is a light of a good white quality. This mixed light constitutes the ordinary diffused daylight, which is generally of a fair degree of whiteness, suitable for the matching of shades. The two predominating hues, orange and blue, are complementary, and combine together to form white light. The reason for desiring a northerly light will now be apparent. The light from that direction is always well diffused, and less liable to change in hue than light from other directions. If the light for colour examination cannot be obtained from roof windows, attention has often to be paid to the outward surroundings in front of the windows where the colour matching is conducted. Strongly coloured objects directly in front of a laboratory window may considerably alter the quality of the light. A red brick wall, for example, or a fresh green tree, if strongly illumined with sunshine, will reflect into the room light of a decidedly reddish or greenish tint, quite unsuited for showing nice distinctions of colour. The writer, in examining a series of reds and orange reds, noticed their appearance considerably dulled and flattened in comparison to their out-of-door aspect, and found this was due to the greenish quality of the light reflected from the trees in front of the window. In studying the true aspect of colours, therefore, attention must be paid to the quality of the daylight. Some colours are more sensitive to an impure light than others, but as a rule, *pigment* colours keep their true appearances better than the soluble dyes. In judging of shades, it must be remembered that a foggy day, the approach of sunset, or an open blue sky, all tend to alter the aspect of the colours by altering the true proportions of coloured rays which they reflect.

Assistance of Artificial Light in Colour Matching.—Colours belonging to the blue and violet glass are often difficult to

match accurately in daylight; but if they be examined in a light having an excess of orange and yellow rays, like ordinary coal gas or lamp light, peculiarities of tone often become visible which could not be detected in a pure daylight. Many greens, blues, crimsons, garnets, violets, and similar shades, can always be better matched with the assistance of artificial light. A deep shade of reddish-blue may show little difference from a blue violet in daylight, but in gaslight the difference becomes greatly accentuated. The reddish-blue becomes dull—almost a black—while the violet blue reddens and becomes more of a red-violet hue. All colours having blue or violet in their composition are greatly modified in a yellow illumination. Gas and lamp light possess only about 20 per cent. of the green, 10 per cent. of the blue, and 5 per cent. of the violet rays present in good daylight; hence all colours belonging to the more refrangible or violet end of the spectrum become much modified in appearance. Reds, scarlets, pinks, and yellows, cannot be correctly judged in artificial light, as the bluish hue, which many of them possess, is entirely lost. Magentas, pinks, and red violets becoming clear reds or scarlets, while the finest tones of yellow become lost. As a rule, soluble colours dyed on wool or silk show greater changes in hue under artificial lights than the pigments. This is no doubt owing to the want of transparency in pigments which, to a certain extent, robs a colour of any dichromatic property it may possess.

Dichroism in Colours.—Dichroism is an interesting property of many colouring matters which influences a gradual change in hue, as a colour is diluted with any diluting medium to produce light tints. A number of dyes and colour liquids exhibit this property in a marked degree. Some of the aniline violets and blues, quinoline blue, the vegetable colouring matters like litmus, archil, soluble

indigo blue, etc., show that the deeper or stronger their solution, the redder in tone they become. Such colours gradually change in hue as they are diluted. It is often observed by colourists, that some reds, when reduced to form a stepping series of reds, go off the proper cast, and show an orange or buffy hue in the light tints, while others reduce in a bluish direction, producing a blue pink instead of a light red. In the same manner yellows, when diluted from strong tones to the light tints, lose their desirable clear lemon hue, and show a somewhat reddish or buffy cast. Such changes are generally owing to the property of *dichroism* in the colours. The following may be taken as a few of the commonest examples of such colour changes:—

<i>Colouring Matter.</i>	<i>Strong Solution.</i>	<i>Diluted.</i>
Magenta.	Cherry Red.	Blue Pink.
Cochineal Carmine.	Red.	Blue Pink.
Picric Acid.	Pure Yellow.	Green Yellow.
Chrome Yellow.	Orange Yellow.	Lemon Yellow.
Gamboge.	Orange.	Pure Yellow.
Chromic Chloride.	Red Brown.	Green.
Prussian Blue.	Deep Blue.	Sea-green Blue.
Quinoline Blue.	Fine Red.	Clear Blue.
Malachite Green (aniline).	Reddish Purple.	Blue Green.
Litmus.	Claret Red.	Blue.
Methyl Violet (aniline).	Purple.	Blue Violet.

The slight change in tone often observed by colour mixers when diluting a colour for making tints arises from this dichroic property. In all such cases as the above, where the rates of colour absorption vary, certain coloured rays gradually disappear or become absorbed, and the light, which is transmitted, being the sum of all the unabsorbed rays, must differ in hue according to the strength of the colour, or the depth of the solution. In testing colours the first duty of the colour chemist is to examine its mixing qualities, viz., its capability of producing good and useful shades by admixture with others. A blue, for example,

when mixed with a certain proportion of yellow, may produce a fine shade of green; while another blue, which to the eye exactly corresponds to the first, may produce a poor dirty shade of green, not at all similar to the other. Many such examples might be given, which naturally perplex the colour mixer; but the true explanation of all irregularities is found in the spectroscopic examination of the colours. Likewise, in examining a colour, it is always necessary to see its diluting qualities in comparison with the colour desired to match.

Bright Colours.—When making a careful comparison with bright colours, the eye soon becomes dazzled and fatigued, so that after gazing intently for half a minute or so, it is unable to discern nice distinctions of hue. In examining scarlets, for example, two may be seen at the first glance to differ in purity of tone; but when the eye becomes fatigued with viewing them too long, they become similar, and assume a dull, faded appearance. The eye is quickly revived to its normal condition again by viewing a complementary colour, which in this case would be green. A piece of coloured material, either dyed cloth or paper, complementary in hue to the colour being examined, is most useful in restoring the eye quickly to its normal sensitive condition. By looking at such colours as magenta, scarlet, orange, bright carmine lakes, or cosine pinks, through blue or green-tinted glasses this eye-fatigue is avoided, and a more correct estimate of the true differences in the colours is obtained. Take for example two bright pinks made from eosine or erythrosine, which dazzle the eye in a short time; no difference can be discerned between the two in their depth or purity of tone; but let them be viewed through a green-tinted glass or gelatine film, and they appear beautiful soft shades of violet, and pleasing to the eye to examine. It may then be noticed that one is stronger in tone, or perhaps bluer or lighter than the

other; a difference which could not be detected with the unaided eye. Thus, complementary coloured glasses or gelatine films may be employed with success in matching or comparing bright colours of this class. The discomfort of fatigued eyes is avoided, the examination can be made leisurely, and the colourist arrives at a more correct judgment of the value of such colours by employing this simple device. The following results may be given as examples of the modification which bright hues undergo when viewed through green-tinted glass :—

Bright reds become almost blacks.
 Purple reds become rich blue violets.
 Magentas become red violets.
 Scarlets become soft shades of russet.
 Bright pinks become soft violets.
 Blue cosine pinks become dull magentas, or reddish violets.
 Oranges become citrines or brown olives.

The Spectroscope in Colour Matching.—Within the limits of a single chapter we cannot enter more fully into the study of this interesting subject; yet we cannot omit making some reference to the great assistance of the spectroscope in all questions relating to the science of colour examination. To those who wish to follow the subject more deeply, and to study scientifically the laws underlying its various phenomena, the spectroscope will be found invaluable. The explanation of many strange modifications of hue observed in colours when viewed in artificial light, is found by studying them with the spectroscope, and observing their absorption bands. Two colours, for example, may match each other closely in daylight; yet show a considerable difference in hue when examined in gas or lamp light. This arises from the fact that colours which appear similar to the eye may be composed of different parts of the solar spectrum; or, in other words, show different absorption bands in their spectra. The unaided eye is unable to detect this. Take as an example

two shades of blue which are closely matched in daylight. On examining them with the spectroscope—a small direct vision one does very well—it may be found that number one blue transmits more red than the other, and absorbs a little of the bright green and violet of the spectrum; while the other—blue number two—absorbs a little of the red, and transmits the bright green, blue and violet, more freely than number one. Yet, in daylight, to the unassisted eye, these two blues were identical in hue. If they be examined in a yellow light, however, such as gas or oil-lamp light, they will at once show a difference. Blue number one will appear redder in hue; while the other will present a greenish-blue appearance, making quite a contrast between the two shades of blue. Thus in many cases which might be mentioned, colours indistinguishable from each other with the naked eye, are shown by the aid of the spectroscope, to be different in character and behaviour. A rule which always holds true with any kind of colour, either soluble dyes or pigments, is *that a perfect match with two colours can never be obtained where the colours show widely different absorption spectra.*

CHAPTER XI.

PREPARATORY TREATMENT FOR "HANK" YARN PRINTING.

IN the hank printing of wool yarns (not that for carpets by the Whytock process which is herein described) the yarn previous to printing must be prepared by treatment with chlorine similar to piece goods. This preparatory treatment is indispensable in printed woollens—where the colours are steamed in the dry state—in order to increase the absorbing capacity of the wool for the colours. In carpet yarn steaming no chloring is necessary, as the printed yarns are steamed in the wet state; and the fixing of the colour on the fibre is similar to that of dyeing. The reason for "preparing" wool both for hank and piece goods printing is that previous to steaming they are dried with heat in a stove, in order to prevent the colours bleeding or running into each other, and thus marring the delicacy of the printed design. After the hanks and piece goods are dried, they are then steamed. If this be done with unchlorinated yarn, it will be found that poor and unsatisfactory colours is the result. Treatment with chlorine is absolutely necessary to open up the scales of the wool fibre (see chap. i.) and thus increase its absorbing capacity, in all instances where the colour paste is dried on the fibre before steaming. When the printed yarns are steamed in the moist or "raw" state, *i.e.*, the colour paste left wet on the yarn, no preparation with chlorine is necessary, as the wool fibre, with the combined action of the steam, moisture, and the assistance of a little free acid, opens its

external scales, and the colouring matter is thereby admitted into the fibre and fixed in the moist state similar to that of dyeing in the dye bath.

The colour chemist can easily demonstrate this for himself by printing several colours on chlored and unchlored yarn, drying the swatches in a dry stove, and then steaming them as usual in the steam chest. It will be found that after steaming and washing the colours on the chlored yarn are full and bright, while those on the ordinary unprepared yarn are poor and unfixed, not to be compared to those on the chlored wool. If, also, the steam in the steam chest be in a "dry" condition, a still greater difference between the two is apparent. If, at the same time of making the above experiments, the colour chemist steam a swatch with the colours *wet* on the yarn, similar to the method employed for tapestry carpet yarn printing, it will be found that the colours come out almost as full and rich as those on the chlored yarn. Hence the reason for not "preparing" carpet yarns for printing.

There are various methods recommended for chloring the wool yarn for hank printing, but all have the same object in view, *i.e.*, the rendering of the wool more absorbent to the dyes. The following method is one of the best:—

The yarn, after it has been scoured and bleached as in chapters ii. and v., is put into a bath containing, for 100 lb. of yarn:—

1½ gallons hydrochloric acid (HCl), at 92° Tw.,
100 gallons water.

Work for 1 hour, and during this time add gradually at 3 different times 25 gallons solution hypochlorite of soda* (*Eau de Javelle*) at 1½° Tw.

* Hypochlorite of soda solution is made as follows:—

2 lb. chloride of lime,
1 gallon water.

When well mixed, then add solution of—

1 lb. soda ash (carbonate soda, pure),
1 gallon water.

Allow to stand for 12 hours, filter, then reduce with water until it stands 1½° Tw.

Then rinse well and pass yarn through a bath containing—

1½ gallons hydrochloric acid per

100 gallons water.

Rinse again, then dry.

Another method recommended is as follows :—

1000 parts wool yarn are steeped in warm water, hydroextracted, and put into a bath containing—

20,000 parts cold water,

590 parts hydrochloric acid, 86° Tw.

While working the yarn in this, add in 1 hour 5 portions of bleaching powder solution, 32° Tw.—of 23 parts each—115 parts in all, and continue working until the smell of chlorine has disappeared. The yarn is then well washed, hydroextracted, and dried.

Bleaching powder solution is made by grinding—

1 part bleaching powder in

1 part water.

Settle, filter, then dilute with water till it stands 32° Tw.

Sometimes chlorate of soda is employed instead of chloride of lime, as the latter has a tendency to make the wool fibre harsh. Strong chloring increases the capacity of the wool to absorb dyestuffs, but it must on no account be overdone, as the wool then acquires a yellowish hue and a harsh, unpleasant feel. In some special cases the yarn for hank printing is prepared also with tin by passing it through a solution of stannate of soda at 3° or 5° Tw., and afterwards through a bath acidulated with sulphuric acid.

Such preparatory treatment is, however, unnecessary in the Whytock process of printing yarns, as employed for tapestry and velvet-pile carpets, table-covers, rugs and similar fabrics. The method of making the printing colours for hank printing is similar to those used in the Whytock process.

CHAPTER XII.

PRINTING OF CARPET YARNS—EARLY HISTORY OF WHYTOCK'S INVENTION—DESCRIPTION OF WHYTOCK PROCESS FOR PRINTING CARPET YARNS.

As the process of printing tapestry carpet yarns differs so widely from all other methods of carpet making, it may be of interest, before entering into practical details, to consider a few notable features of the process. The method of printing the various colours on the yarn, which is most ingenious, was invented and patented by a Mr. Richard Whytock, of Edinburgh, in the year 1832. By his method carpets can be made of dyed or coloured warps without new blocks being required for each new pattern. The carpets may have a looped surface like the Brussels, or the loops may be cut in the weaving, giving a velvet pile like the Wilton carpets.

As very little information has been published regarding the early days of this invention, a few details may be of interest, gathered as they were by the present writer from those who were well acquainted with the inventor. Richard Whytock was the son of a minister in Dalkeith—a town near Edinburgh, and was born about the year 1775. Having a strong mechanical turn of mind, he spent much time in experimenting in a little workshop he had for the purpose. One day having accidentally drawn out a worsted thread from a piece of printed delaine, which was then fashionable for ladies' gowns, he observed that the single thread was coloured various colours at stated intervals according to the design printed

on the delaine. The idea struck him,—could he not print single threads with colour in such a manner that, when a number of them were woven together, they would make a coloured carpet? By following out this idea he produced, after several years' experimenting, the process of carpet yarn printing known as the Whytock process, now employed in making tapestry carpets, velvet table-covers, sofas, rugs, and similar fabrics.



Richard Whytock. Inventor of Tapestry Carpet Printing.
(Born 1775, died 1856.)

Richard Whytock spent much of his time in quietly working out his mechanical ideas, and was well known for his charity. He died a bachelor in 1856, leaving £35,000 to be divided among his brother's family. The invention was first tried in Edinburgh in 1832 in a part of Queensberry House in the Canongate, and in 1833 it was removed to St. Ann's at Lasswade, which was formerly a brewery.

About the year 1846 Messrs. John Crossley of Halifax bought the patent from Whytock for £10,000.

In 1841 a series of trials were made to print the colours on the yarn and steam it in one continuous process, but, after costing nearly £1000, the idea was abandoned.

Whytock's invention shows a sound knowledge of the arts of weaving and dyeing, as well as mathematics. Such a process, even though conceived, could not have been brought into practical work except by one thoroughly acquainted with these arts. Like many other useful inventions, its early progress was slow and disappointing. Manufacturers and dealers were not in favour of the new fabric, and printing drums were erected only a few at a time. After fifteen years, however, in 1847, we find fifty-six tapestry looms working, the greatest number of these being employed in the firm of Henderson & Widnell at Lasswade, near Edinburgh. The great success which has attended the tapestry carpet industry is owing principally to the energetic and enterprising manner in which the eminent carpet firm, Messrs. John Crossley & Sons, of Halifax, entered into its manufacture. It has now become an important branch of textile industry, extending over the whole world. By employing the same principle of printing and weaving, all kinds of beautiful and inexpensive velvet pile carpets, table-covers, sofas, rugs, etc., may be produced at a price within the reach of all. Many improvements in details have, of course, been made on Whytock's invention of 1832; but the principle of imparting to the yarns their various colours remains practically unaltered. In Brussels carpet manufacture all the yarns are dyed self-colours in the dye bath, each separate thread representing one colour in the carpet. In order to have a small piece of a colour in a Brussels a thread of that colour must traverse the whole pattern. The colours in Brussels are limited to five or six, and if another shade is desired, it can only be

inserted by the process of planting, which is substituting it at the desired place for another colour already working in the carpet. Whytock's process overcomes this inconvenience. A single tapestry thread is printed various colours, and there is practically no limit to the variety of shades which can be employed. This, indeed, has been brought forward by some writers as a positive objection to the tapestry process, as the results are apt to become vulgar and "offensive to any one having artistic taste". But the fault here lies, not in the process itself, but in the taste of the colourist or designer. A soft, harmonious colouring, which would satisfy the most fastidious taste, can be employed with great effect in tapestry carpets. No doubt the colouring in many tapestries is crude and garish, but such are generally intended for foreign export where they have a ready market. With many nations there is a strong demand for bright, showy colours and glaring contrasts, which, to our eye, would appear offensive. This freedom in the employment of colours, then, instead of being a fault in the tapestry process, is indeed a positive advantage, as it enables the manufacturer to supply the demands of other nations, though their taste, perhaps, be not the most cultivated. Within late years tapestry carpets, as a whole, have greatly improved in colouring; the many excellent productions from our best firms have, no doubt, done much to elevate public taste. In Brussels all the dyed threads lie in layers, one on top of another, under the surface of the carpet, and only reappear on the surface at the certain place where they are required to produce the design. In this way a large amount of dyed yarn must, of necessity, be concealed under the surface. In a Brussels of five colours, or a five-frame carpet, only about one-fifth of the dyed worsted forms the surface of the carpet and is visible; while, roughly speaking, about four-fifths lies under the surface and is lost to view. By Whytock's process this

great loss of valuable material is altogether avoided, all the coloured yarn in the tapestry carpet being on the surface and visible. Another point of advantage is the saving of space with tapestry looms; a Brussels loom occupying three times the space in length that a tapestry one requires. In the early days of Whytock's invention the yarn was wound on the printing drum from bobbins, by rotating the drum by means of a hand crank, while a simple arrangement guided the threads across the breadth of the drum. At that time the colours were applied to the yarn, not by means of a printing pulley and colour box as now employed, but with straight wooden sticks or rulers which were dipped into the colour paste and then applied to the yarn across the drum. The edges of the printing sticks were covered with felt. Originally the printing drum seems to have been made of tin and covered over with waterproof cloth. The point at which these colour rulers were applied was midway up the drum, where a ledge or guiding shelf was erected to keep the ruler exactly parallel to the edge of the drum. The introduction of rollers or pulleys running in a small box and colour paste, and printing at the bottom of the drum instead of the side, was a great improvement on the old system.

* Like the majority of clever inventions, Whytock's method of colouring tapestry carpets is very simple in theory; yet in actual practice, the many little important details requiring attention give it a complexity which renders it difficult to comprehend at first sight. To the reader who has never seen the printing drums, or the process in operation, a mere verbal explanation will be of little service. We have here in Fig. 8 an illustration of the modern tapestry printing drum with all its accessories in working order. This will give a clearer idea of the method of printing than any words can convey. The following explanation, combined with the assistance of the picture and diagrams, will give an in-

telligent idea of the tapestry process of carpet making to those unacquainted with it in actual work. The design of the carpet pattern is first painted on paper divided into little squares or parallelograms, each little oblong representing a loop in the finished carpet (see Fig. 9). This coloured design, which somewhat resembles a mosaic, is pasted on a board,



FIG. 8. The Printing Drum.

and hung beside the printer. The design board is seen to the extreme right of the illustration, where a boy is pointing on it with his finger, evidently engaged in reading off the colours to the girl printer at the drum.

The circumference of the large cylinder or drum, which is made of wood, is first covered with varnished or glazed cloth to

prevent the dyes from entering and staining the wood. It is then wound evenly round with one layer of the carpet yarn, giving it the appearance of an immense bobbin, covered with one layer of thread. The drum, as seen in our illustration, is covered only half-way across with yarn, thus making only half the number of carpets. Underneath the drum and running in the direction of its axis is a small set of rails, on which runs the carriage for the colour boxes for supplying the various colours to the yarn. A number of these boxes are seen around the boy—the “boxer” who is ready to supply any colour box which may be required. In each box, and partly submerged in the colour paste, is a roller or pulley, varying in width from $\frac{1}{4}$ to $\frac{1}{2}$ inch, which, as the colour box runs underneath the drum, presses up against the yarn by means of springs adjusted to the carriage, and thus rules a streak of the colour right across the yarn on the drum. Several such ruled lines of colour are seen in the illustration. Down the length of the design is a numbered scale (see Fig. 9), each number corresponding to the oblongs or the stitches on the ruled paper; while a similar scale is fixed round the rim of the drum, these printing drums varying greatly in circumference according to the requirements of the patterns to be printed. To show how the printing operation proceeds, we may take a very simple example as seen in Fig. 9, which represents a chequered design in red, blue and white; the black oblongs representing red, the striped ones blue, and the white ones white. The drum, which is ready covered with yarn, is turned round on its axis till 1 on its index is reached, when the first drum is ready to be printed. The first colour which comes in the design is red, i.e., a black square, so a colour box containing the requisite red colour is placed upon the carriage and made to run under the drum. In doing so, the pulley which it contains presses up against the yarn on

the drum, and leaves a red stripe as it traverses across it. The next colour to print—proceeding down the design and not across it—is a blue, *i.e.*, a striped square. The drum is now moved round one division to 2, so that the line of colour already printed is just escaped, and the blue colour box substituted for the red one, and run across the rails as before. This leaves a blue stripe side by side with the red one already printed. It will be seen

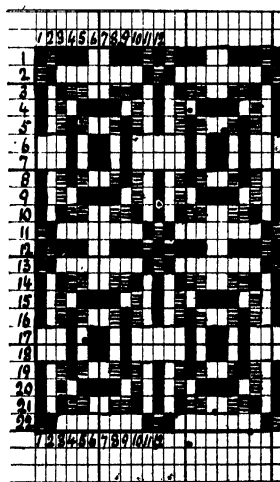


FIG. 9. Carpet Pattern as painted on design board.

from the design, (Fig. 9) that the next three spaces, always reading down the design, are all red, 3 to 5, so the red box is again put in, and 3 stripes ruled, the drum being turned one number after each stripe. Numbers 6 and 7 are left blanks, as they have to remain white yarn, so the drum is turned round to 8 on index; here follow three stripes of red, then blue is run in at 11, red again at 12, blue again at 13. Then follow three stripes, 14 to 16 of red, 17 and 18 are

left blanks, 19 to 21 are red, and the first drum finishes with a blue stripe at 22. When all these coloured stripes are made, according to the design board, the drum is finished. The yarn is then carefully taken off, the number attached to it, *i.e.*, drum 1, and it is then carried away to the steaming which fixes the dyes upon the yarn. The drum is again covered over with yarn as before, and drum 2 is begun. The first colour here is blue, the blue box is run through, making its stripe of blue, then follows one of red. From 3 to 10 are left blanks, so the drum is turned round to 11 on its index, and a stripe of red made. Then follows blue at 12, red at 13, blanks from 14 to 21, and drum number 2 finishes with a stripe of red at 22.

The yarn is now taken off, number 2 attached to it, and then steamed as before. Then follows drum 3. The first stripe here is red, 2 is a blank, 3 a red, 4 and 5 are blues, 6 and 7 blanks, 8 and 9 blue stripes, 10 a red, then blank, red, blank, red, then at 15 come 2 blues, 2 blanks, 19 and 20 blues, 21 red and 22 blank. This finishes drum 3, and so the printing process continues until all the drums are printed according to the design paper. In actual practice the printer puts in all the parts requiring one colour, before proceeding to use another colour, and all the light, delicate tints like buffs, light sages, drabs, etc., are printed before the dark shades. Suppose, then, for the sake of simplicity, that there were 100 threads of yarn wound round the drum, all these 100 threads would be coloured exactly alike and each would make one single coloured thread for 100 duplicate carpets. When all these parti-coloured hanks of yarn are steamed, washed and dried, they are arranged in their proper order, according to their attached numbers, and each thread is adjusted in the setting frame to its right position. We then have the threads dyed at the regular prearranged intervals, corresponding exactly to the coloured design which

was copied; but instead of one copy we have 100 copies, or repeats of the same pattern in one long continuous web or warp. The design, as it appears on the coloured threads in the setting frame, has a very elongated appearance, as represented in Fig. 10, but this disappears in the weaving, as the threads are drawn up into loops and contracted, bringing out the pattern of the carpet exactly as it appears on the design paper. It will be readily seen that Whytock's process of printing is a great saving in labour compared with



FIG. 10 represents the elongated appearance of the design on the threads ready for setting.

the block-printing style. In block printing, a new block is required for every new pattern or design, but by Whytock's method no blocks are required, and the printing pulley serves for all patterns as the one pencil serves for drawing all kinds of designs, or the one pen serves for any style of writing. If an object, say a little touch of pink in a flower, occurs in a tapestry pattern, the block printer, to give the requisite touch of pink to 100 carpets, would require to apply his block 100 times, but if the yarn be wound round

the printing drum 100 times, it will be seen that one streak of the pink colour across the drum would give to the flower the requisite touch of pink for 100 carpets. If the yarn be uncoiled from the drum it would be found dyed in 100 places equi-distant from each other, and at exactly the spot where it was wanted to tip the flower with pink from end to end of the 100 carpets. Fig. 9 represents the design as painted for the guidance of the printer. Fig. 10 represents the elongated pattern of the printed yarn arranged in proper

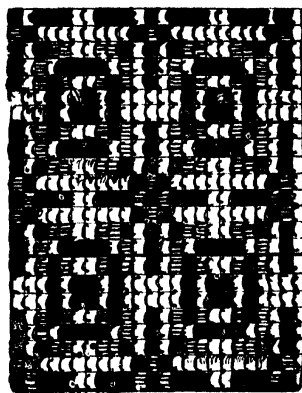


FIG. 11 represents design on Woven Carpet.

order by the setters, and ready for being wound upon the beam and woven into carpet. Fig. 11 represents the woven carpet completed; the pattern no longer assumes the elongated appearance as seen in Fig. 10, because the yarn, in being drawn up by the wires in the weaving to form the loop surface, becomes contracted, and the design regains its correct proportions. In a tapestry of good quality, having nine wires or loops of thread per inch, 5 inches of printed yarn become contracted into 2 inches of woven carpet;

while in a poorer quality, with only six wires per inch, 3 inches of yarn form 2 inches carpet. In the poor qualities of tapestry the yarn is drawn out to cover as much surface as possible.

The above short description of tapestry carpet printing, which has been simplified and divested of its technicalities as much as possible, will no doubt enable those readers unacquainted with this special branch of textile manufacture, to follow the process intelligently. In tapestry printing, one becomes impressed with the great importance of attention to the minutest details. Without this the process would become most uncertain, and the many separate threads would become hopelessly confused. Inexperienced or careless printers, in not paying due heed to the proper tying of each separate hank on the drum, the numbering of each drum of yarn as it is printed, the accidental breaking of a thread, or the emptying of a bobbin while the drum is filling, or omitting to tie the certain kind of knots on the thread ends in order to guide the winders, and many similar little points, all apparently mere trifles in themselves, if not attended to, will give rise to serious trouble and waste of material in the subsequent operations through which the yarn has to pass.

CHAPTER XIII.

CARPET YARN PRINTING (*continued*)—GLAZE CLOTHS—"FURNISHING" THE YARN—COLOUR PULLEYS AND BOXES—RUBBING—AUTOMATIC EQUALISERS—SHARP OUTLINES—DYEING YARN PREVIOUS TO PRINTING.

IN these days of keen competition, when prices are low and merchants are found so hard to please, it requires all the energies and attention of the carpet manufacturer to keep himself abreast of his competitors. In tapestry carpet making, as in every other branch of industry, much success depends upon attention to details, and the harmonious co-operation of all those in charge of the various departments of manufacture. The design of the carpet, and its selection of colours, the printing, setting and weaving, all contribute their own special quota towards the making of a good and successful carpet. Unfortunately, however, the demand in some places for poor qualities of carpet has so lowered the standard as almost to deprive those engaged in their manufacture of any pride in the beauty of their handiwork. The maxim of Michael Angelo in regard to art, that "Trifles make perfection; but perfection is no trifle," can be applied with equal truth to tapestry carpet printing. It is the consideration of a few of these details in printing that will now occupy our attention.

Oil or Glaze Cloths.—The varnished cloth which is used for covering the drum previous to printing requires to be perfectly clean when used for light-coloured patterns. If they be deeply stained with dye from a former print, the wet colour paste

draws out the colour from the cloth and stains the delicate tints of the pattern which is working. A light cream-coloured ground might be found spoiled with a greenish or reddish hue from the glaze cloths which had been employed. If the pattern be a light-coloured and important one it is better to use fresh cloth. The steam drying cylinders over which the washed glaze cloths are passed (see Fig. 12) should be cleaned at least once a week to prevent the formation of a dirty crust or scale, which readily adheres to the cloth as it passes over the cylinders. If the copper of the cylinders be very dirty, a scrub with a little carbonate of soda and water will effectually cleanse them. In the earlier days, when things went with more leisure, the glaze cloths were well scrubbed with water and hand brushes and then hung up to dry in a well-ventilated chamber. The quicker method of drying them over heated cylinders undoubtedly helps to make the cloth brittle and more easily cracked. Care must be exercised in having the cylinders neither too hot to burn, nor too cold to imperfectly dry the cloth.

"Furnishing" the Yarn.—If the colours be barely printed on the yarn they come out thinner and lighter in colour than the shade desired; and should an excess of colour be used, the opposite effect is produced in making the colours much deeper in tone than they should be. In both instances a colour which might be carefully matched to the standard shade by the colour chemist can be put off the desired tone in the printing by using either an insufficient or excessive amount of colour. This is sometimes a cause for difference of opinion between the printmaster and colour chemist; and only those experienced in the business can believe how much a colour may be altered in appearance, either lighter or darker, according to the bare or full manner in which the colour has been printed. It is quite possible to make the same colour present three stepping shades, light, mid and dark, by applying

the colour paste, barely, in medium quantity or excessively to the yarn on the drum. Hence arises the necessity for preserving all through the pattern a medium and uniform amount of colour during the printing. In regulating the amount of colour to be administered, the printing overseer must attend to the wipers or doctors on the colour box, that they be neither too wide nor too tight, and that the spring of the carriage of the colour box be so adjusted as not to press the pulley too firmly against the drum and thus squeeze out the colour. It is, however, no easy matter to produce exactly the same shade of colour on yarns widely different in quality. Different yarns require slightly different treatment, and it is only from experience that the print overlooker learns to adjust the little details to produce satisfactory results. Some of the poorer or "hungry" yarns absorb a much larger quantity of colour than those of fine quality; and the finer the lustre of the wool, the richer and fuller is the colour produced. In printing fine yarns the colours as a rule are put on as thinly as possible, as the wool is easily satisfied; but when the yarns are heavy or of an absorbent nature, and contain what is known as *kemps* or dead hairs, a greater quantity of colour is absorbed. It is impossible to get rich and full-bodied colours on a harsh, lustreless wool; they look dry and impoverished. With such yarns the colour box is often used without wipers in order to get as much colour on the yarn as possible. When printing large patches or grounds of a single colour it is always necessary to use the colour liberally; a barely furnished ground is sure to turn out unsatisfactory, being alike poor in its quality of colour and stripey in appearance. Often a successful pattern is spoiled by having a blotchy, uneven ground; this, in many cases, might be overcome by printing more fully and keeping that uniformity of colour throughout the whole pattern. Rubbing the wet drum carefully with rollers, or, what is

even better, brushing it with a small hand brush, is of great assistance in getting out level grounds.

Pulleys and Colour Boxes.—The printing pulleys or rollers have long been made of wood, and when first used they had round their edge a covering of felt. This absorbent material has now been dispensed with. Pulleys made of vulcanite (a compound of indiarubber, sulphur and white lead) are now largely used, as they are found to be much superior to the wooden ones. Vulcanite pulleys, being thinner, do not occupy so much space in the colour box, do not warp or twist, nor do they absorb the dyes and become stained like those made of wood. The great disadvantage of the wooden pulley is that it readily becomes dyed with the colour in which it works, and no amount of washing can remove the stain. Such dyed pulleys are unsuitable for printing delicate tints, as the colour paste draws the dye from the wood and spoils the colour printed. This danger is altogether avoided by using the vulcanite pulley, which can be readily cleaned for fresh use. Their initial expense has proved a hindrance to their more general adoption, but if their longer durability, their saving in time and labour, and the more satisfactory results obtained, be taken into consideration, it may be found that the cost is not so great in the long run. Another kind of pulley in use has a vulcanite edge and cast iron flanges on either side, which are painted over with a protecting coat of paint or enamel. But the fatal objection to this style of pulley is the presence of iron. The protective covering of enamel, pitch or whatever is used, becomes rubbed or chipped off in course of usage, and the iron, being exposed, comes in contact with the acid colour paste and a chemical reaction sets in which is highly deleterious to the colours. *Metal of any kind should never come in contact with the printing colour.*

Colour Boxes.—Wooden colour boxes have the same defect.

as wooden pulleys in their readiness to absorb the strong dyes, and it requires the utmost vigilance on the part of the print overlooker to see that delicate tints are not worked in deeply stained boxes. Where the number of colour boxes at the command of the printer is limited, it requires much care to select those boxes most suitable for the colours to be employed. A good idea is to have the wooden colour boxes lined inside with a protective casing of thin vulcanite. This is done by having an inner box of thin vulcanite, $\frac{1}{8}$ inch thick, which is made to slip inside the wooden box and fit tightly, being screwed along the top with brass screws. This forms an excellent covering for the wood, rendering the boxes easily cleaned inside, as the vulcanite does not absorb the dyes. Care must be exercised in washing the boxes so lined, as hot water warps the wood; which twists and cracks the vulcanite. Cold water only should be used in their cleansing. When the inner vulcanite casing becomes much broken—and it is somewhat brittle—it should be taken out and a fresh one substituted, otherwise it harbours particles of dirt and colour in the crevices which cannot be readily removed. Boxes in such a condition are a source of trouble, and often cause delicate shades to be spoiled.

Rubbing.—During the operation of printing, each stripe of colour made by the pulley is left with ridges of an excess of colour on either side; and in order to equalise and distribute this excess of colour, the operation of rubbing has to be resorted to. This consists in rolling the stripes of coloured yarn with the little wooden hand rollers, so as to rub the colour paste well into the yarn and distribute the amount of colour as evenly as possible. Where the stripes are too narrow to be rolled, as in single pulleys, the rubbing has to be done with narrow stripes of vulcanite. To bring out satisfactorily the style of work known as Moresques or Arabesques, consisting of tracery designs

formed of little variegated dots, it is necessary to give careful attention to the rubbing of those parts, and also to have the colours much darker in shade than what is intended.

Automatic Rubbers.—An automatic rubbing apparatus for tapestry carpet yarns has lately been introduced into America and this country whereby the operations of printing and rubbing are performed at one and the same time. Mechanical rubbers are employed usually in pairs and fixed on opposite sides of the colour pulley. They can be automatically thrown into, or out of, their operating position, as the colour box and carriage move in opposite directions. Either single or double rubbers can be used, and they are so adjusted as to run exactly over the ridge of superfluous colour made by the printing pulley, and so equalise the colour as it is being printed. Automatic “equalisers,” as they are termed, have been employed in America for some time, and are considered an advantage.

Sharp Outlines in Printing.—It is always desirable in printing tapestry carpet yarns to have the colours with sharp, clean-cut edges, and not presenting a blurred outline. From the earliest days of Whytock's invention, this has been considered the great defect in the tapestry process. Writers dealing with this subject have complained of the “muddy unsatisfactory appearance” of the tapestry carpet, but by careful attention to a few points now to be considered, this imperfection may, to a great extent, be overcome. The yarn, if in the slightest degree damp, will cause the colours to run and thus make a blurred edge. If the colours be too thin and watery they give the same unsatisfactory result; such colours require to be thickened by boiling with flour. If the carriage of the colour box does not run smoothly, but jolts and jerks, or if the printing be done too hurriedly, the colour paste is splashed upon the drum, thereby producing dirty work. Some aniline colouring matters, such as the

Benzaldehyde Greens, Bismarck Brown, some Oranges and Magentas when used in strong solutions, have a tendency to run when printed on the yarn. Colours which are found to run badly and stain the adjoining white yarn should be discarded by the colour chemist. Hyposulphite of Soda ($\text{Na}_2\text{S}_2\text{O}_3$) is a useful mordant to add where colours show signs of bleeding. In special cases, when a dark colour edges a white or light buff, the dark shade requires to be made specially thick for edging, by boiling it with the addition of a little British gum. This gives the edging colour a sufficient consistency to prevent bleeding into the delicate tint. In moresque and tracery work, where single pulleys are used, it is necessary to employ a colour much darker in tone than what is intended, as the bare printing necessary for such work considerably lightens the colour.

Dyeing the Yarn previous to Printing.—When the beauty of a pattern largely depends upon a clean and sharp-edged outline, as in many Brussels and Chenille carpets, it is not well adapted for tapestry printing. It is most difficult—nay, impossible—to obtain the same beauty of outline by the Whytock process. For example, to get out successfully a single pulley outline, of light buff or white, in the midst of a patch of dark crimson, red, black or similar strong colours, is no easy matter. During the printing and steaming the narrow outline gets destroyed by the adjacent deep colour, and where a delicate clean outline was expected there appears a poor blurred suggestion of an outline, if indeed it be not altogether obliterated. Designs of this nature ought, if possible, to be avoided by the tapestry carpet designer; but now-a-days manufacturers, to please the merchants, are often glad to attempt anything and everything, and it so happens that patterns of such a nature are sometimes taken in hand to print. In such circumstances it will be found of great assistance in getting out more satisfactory work to

dye all the yarn the light tint previous to printing. This method, which is much used in Germany, shows many advantages. A more successful carpet or table-cover is



FIG. 13. Illustration of difficult pattern to print successfully by Whytock process, owing to the delicacy of outlines.

obtained, but it is only the best quality of goods that warrant the extra expenditure of time and trouble which it incurs. Some of the German works employ it with beautiful results,

which never could be gained by simply printing on the white yarn in the ordinary manner. After the yarn has been dyed in the dye bath the necessary light tint which forms the outline, it is thoroughly dried and wound upon the drum in the usual way, and printing proceeded with as usual. It will be found that the results obtained by this method are much superior to those got by printing in the light tint. The illustration (Fig. 13) represents a tapestry carpet design of this difficult class, where the outlines, to make the pattern effectual, must be sharp and clean. In printing such a carpet as this the yarn requires to be dyed the light outlining tint, to produce anything like a satisfactory result. The advantages to be gained by dyeing the yarn are threefold. First, as no colour requires to be printed on where the light tint occurs, the yarn at those places is kept perfectly dry, which enables it to remain clean and unsoiled. Second, the yarn, after being dyed, has acquired a certain increased affinity for the colouring matters, as the Glauber salts and sulphuric acid act as a mordant for the dyes, which fixes the colours readily on the wool and prevents them running. Third, another advantage to be gained with dyed yarn is the soft harmony of colour it sheds over the whole pattern, giving it a beauty of effect similar to viewing any coloured designs through a tinted glass. Fine qualities of velvet table-covers printed in this manner have a subdued harmony of colour and general soft effect which would be unattainable by printing in all the colours on the white yarn. As already stated, though the results obtained by this method are much superior, it is only the finest quality of goods that warrant the increased expenditure of time and labour it involves.

We will consider in our next chapter the steaming of the coloured yarns.

CHAPTER XIV.

STEAMING OF PRINTED YARNS—STEAM CHEST—STEAMING PRESSURE—DURATION—EFFECT OF STEAMING ON WOOL FIBRE—EXCESS OF MORDANTS.

THE colours, after being printed on the yarn, require to be permanently fixed or dyed into the fibre of the wool, and in order to accomplish this the printed yarn must be submitted to the action of moist heat or steam. The question of yarn steaming is one of considerable importance in the tapestry carpet making, and much success depends upon its intelligent management. Under the influence of steam the wool fibre absorbs the colouring matters, and becomes permanently dyed in a manner similar to that of the ordinary dye bath. The steaming operation consists in placing the printed hanks of yarn, still wet with the colour paste, into a long iron box or steam chest, and there they are submitted to a course of steaming, under gentle pressure, for nearly thirty minutes. After this treatment, the colours are found to have penetrated into the fibre of the wool and become fixed. During the process of steaming the epithelial scales, which constitute the exterior of the wool fibre (see chapter i., Fig. 1), are, no doubt, opened out, exposing the interior of the fibre to the colour. This possibly explains the reason why acid in the colour paste assists the fixing of the colour, by opening these exterior plates or scales of the fibre. (See A, Fig. 16, action of oxalic acid.) The mode of steaming tapestry carpet yarns is, in many respects, similar to that employed in the sister art of calico printing.

It is difficult to state with any accuracy the exact date when this method of fixing colours by means of moist heat was introduced; but the idea was of gradual development, as the early experimenters seem to have been slow in arriving at satisfactory results. Many trials were first made with dry heat, by passing the printed goods over heated cylinders, or hanging them before stoves; but the results obtained by this treatment were far from satisfactory. Towards the close of last century Dr. Bancroft published his researches on the fixing of colours by means of the "heat of steam"; but in these experiments he took elaborate precautions to exclude the moisture of the steam. The general opinion in those days, and it seems a very natural one, was that the moisture of the steam would cause the printed colours to run into each other. This impression, however, has now been proved by experience to be a wrong one. The results of his experiments were not encouraging, but had he not been so careful in excluding the moisture of the steam, he would, no doubt, have been more successful.

Fixing colours on wool by steaming was not largely employed until about the year 1830, only two years prior to Whytock's invention of tapestry printing. A few of the minor details may be worked in a slightly different manner in the various carpet works, but the rationale of the process is in all cases the same, *i.e.*, to fix the dyes into the fibre, and preserve, as much as possible, the strength and lustre of the wool.

The yarn, after being printed, is taken off the drum and carried suspended between two short poles towards the steaming department; its own proper number is attached, and after undergoing a necessary inspection, it is then allowed to pass on to the steaming. The printed yarn, divided into hanks, is then carefully deposited upon the steaming carriage,

which consists of a long iron frame or tray mounted on wheels running on a small railroad into the steaming chest. When the carriage is sufficiently filled with the printed hanks, it is run into the chest, the door is tightly clamped by means of screws, and steam admitted into the chamber by valves.

Steam Chest.—The steaming chest or cottage consists of a long horizontal chamber built of iron plates, and varying in dimensions according to the space and requirements of the carpet work. This chest is permanently closed at one end, while the other is fitted with a tightly-closing door, which can be fastened steam-tight by means of clamping screws. These doors, which are very heavy, are raised in a manner similar to a portcullis, with a chain and counterpoised weight at the other end of the chamber. When the chests are wide, and have a roof nearly flat, it is necessary to have them provided inside with a second or false roof in order to catch the drops of moisture which collect on the roof and would otherwise fall on the yarn below. This second roof is made so as to come within a few inches of the sides of the chamber to enable the condensed moisture to run off and find its way to the floor. Where the steam chests are of the narrow type with a high roof of the "kennel" shape, an inner moisture roof is unnecessary, as the collected drops readily run down the sides. The chest is fitted with valves and steam gauge so that the pressure inside may be carefully regulated. Every care of the steam attendant is required to keep up a regular method of working, as insufficient or excessive steaming produces unsatisfactory results, which often give rise to future trouble.

Steaming.—Various systems have from time to time been employed for steaming the yarns. Sometimes the hanks are laid on a network of stout cord, a blanket, or galvanised iron netting stretched across the iron frame of the carriage. At

other times knife edges made of slate are used for the same purpose. The more general method now in use is to steam the yarns on wooden boards previously covered with a thick layer of sawdust, chopped chaff, or oat husks, used either separately or mixed in varying proportions. The printed hanks are deposited on this prepared bed, and after steaming they are lifted and removed to cool. A sprinkling of fresh material gives a renewed and clean surface for other hanks to be steamed. Oat husks are preferable to sawdust when they can be obtained, as they are not of so absorbent a nature, and therefore have not the same tendency to draw the colour out of the yarn. In the steaming process the subject of pressure is one of much importance, as it touches upon questions of a physical as well as a chemical nature. Notwithstanding the valuable investigations which have already been accomplished in this direction by experimenters like Bancroft, Rosenstiehl, Walter Crum, and others, there still remains room for further research. For carpet yarns a gentle pressure of about 3 lb. for twenty to thirty minutes is considered to give the most satisfactory results. The pressure of steam employed may be designated in three ways, namely :—

1. Temperature inside the steam chest.
2. Pressure of atmospheres.
3. Pressure of pounds,

and these three systems are mutually interchangeable. The ordinary pressure of the atmosphere is taken at 15 lb. per square inch (14·7 to be more correct), at which pressure water boils at 212° Fah. This being the ordinary air pressure, it is generally taken as the starting-point, thus 212° Fah. represents 0 lb. pressure, or if absolute pressure is desired it would be 0 + 15 lb. per square inch. Thus—

atmosphere	pressure	represents	15 lb.	per square inch.
"	"	"	$7\frac{1}{2}$	"
"	"	"	$3\frac{3}{4}$	"
		etc.		

As the temperature of the steam rises, there is a corresponding increase in pressure, which may be seen from the following table of figures, taking the boiling-point as the standard :—

212° Fah.	= 0 lb. pressure.	
215°	= 1 lb.	„
220°	= $2\frac{1}{2}$ lb.	„
224°	= 4 lb.	„ or over $\frac{1}{4}$ atmosphere.
230°	= $6\frac{1}{2}$ lb.	„
233°	= $7\frac{1}{2}$ lb.	„ or $\frac{1}{2}$ atmosphere.

Any higher temperature is rarely required, and, indeed, is not advisable, as the hot steam produces a chemical change on the wool, which is highly detrimental to the fibre. The effect on the structure of the wool fibre which has been overheated may be readily seen from illustration B, Fig. 16. From the above figures it may be seen that the various standards for indicating steam pressure are mutually convertible. Thus, when goods are said to be steamed at $7\frac{1}{2}$ lb. pressure, or $\frac{1}{2}$ an atmosphere, it is understood that the temperature inside the steam chest should be about 232° to 233° Fah., or if steamed at $2\frac{1}{2}$ lb. pressure, it should correspond to 220° Fah., etc. In the actual steaming of yarns, however, it is rarely possible to find the pressure and temperature inside the chest to correspond exactly, as the air present in the steam chest and the gases evolved from the yarns tend greatly to increase the pressure after the chest becomes heated. This is a question of much importance, which is apt to be overlooked in many cases. Thus it is possible to have the steam chest gauge showing a pressure of 2 to $2\frac{1}{2}$ lb. per square inch, while the temperature inside the chest only registers 200° to 216° Fah.

The following figures have been taken from actual experiment :—

Temperature inside steam chest.	Pressure inside steam chest.	{ This shows the necessity of having escape valve blowing off constantly from the chests to get rid of the cold air and acid vapours present inside.
209° Fah.	= 3 lb.	
212° „	= 2 lb.	
216° „	= $2\frac{1}{2}$ lb.	

The most suitable steam gauge for yarn steaming is the simple mercury gauge, as the acid vapours from the colours very soon destroy sensitive spring gauges. Much trouble often arises from this cause.

Duration.—The duration of steaming carpet yarns is generally from twenty-five to thirty minutes at a gentle pressure of $2\frac{1}{2}$ to 3 lb., but the time varies according to the pressure employed. If steamed without pressure, sixty minutes are required. It will be seen that the pressure employed in yarn steaming is not so high as in woollen cloth steaming, where a pressure of 7 to $7\frac{1}{2}$ lb. ($\frac{1}{2}$ atmosphere) for thirty minutes is employed.

High pressures, and consequently high temperatures, are to be avoided in yarn steaming, as they tend not only to decompose some colouring matters, but to injure the wool fibre itself. Wool is highly sensitive to the action of heat and the less pressure employed the better. A moist steam is considered by all authorities to give the best results.

The amount of steam which escapes from the chest should be sufficient to carry off the acid vapours which are liberated in the steaming, otherwise unsatisfactory results are sure to arise. Sulphurous acid gas (SO_2) is absorbed to a certain extent by the yarn during the bleaching, and this acid, along with volatile acid mordants, added to the colour paste, becomes liberated under the heat of the steam, and causes the atmosphere inside the chests to have an acid reaction. It is therefore necessary to have a blow-off valve attached to the chest in order to free the steam from an excess of acid vapour. Overcrowding the chests with yarn is a danger which has to be avoided, from the fact that the amount of acid gases liberated may prove so excessive as, in some cases, to reduce or decolourise some of the colours on the printed yarn. The acid vapours condensing on the iron roof of the steam chest readily dissolve the metal forming a salt

of iron, which, if allowed to drop on the yarns, is apt to produce a stain or cause unevenness in the colours.

Another reducing agent which is evolved to some extent in the steaming process is sulphuretted hydrogen, produced from the sulphur which is naturally present in the wool fibre to the amount of about 3 per cent. The brown stain left on bright metal on which wool has been heated is owing to the sulphur it contains and this fact has not to be overlooked in dyeing delicate shades in metal dye baths. The evolution of sulphuretted hydrogen during steaming may be demonstrated by padding a piece cotton with paste containing a solution of acetate of lead. The swatch, which previous to steaming is colourless, will be stained a brown on the exposed surface after steaming, from the formation of the black compound sulphide of lead. In woollen cloth steaming it is customary to hang swatches or "fents," padded with sugar of lead, inside the chests to absorb the sulphuretted hydrogen gas. The presence of this gas is more conspicuous where a high temperature is employed, as the wool fibre then shows signs of slow decomposition. In all processes where the treatment of wool is concerned, such as spinning, scouring, bleaching, dyeing and steaming, the great aim is to preserve as much as possible the original beauty and strength of the fibre.

Mordants of a corrosive nature must be used with great caution where colours are fixed by steaming, as the wool fibre, under the influence of heat or pressure, is more readily corroded and tendered. The injurious effects of over-steaming wool, or of using an excess of mordant, may be seen by studying the microscopic appearance of the fibre. The illustrations here given were drawn by the writer from the actual specimens under examination. Fig. 1. (see chap. 1.) represents the typical appearance of good wool fibre (unsteamed) showing the external cells or scales overlapping each other.

Fig. 14 represents the fibre after being over-steamed, showing the scales lying closer and firmer to the stem. This gives rise to felting of the yarns if the fibres are interlocked when the external scales close.

Fig. 15 shows very clearly the corroding effect of an excess of tin crystals ($\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$). The external cells are opened, giving the fibre a rough harsh feel to the touch. The wool in this case was tendered.

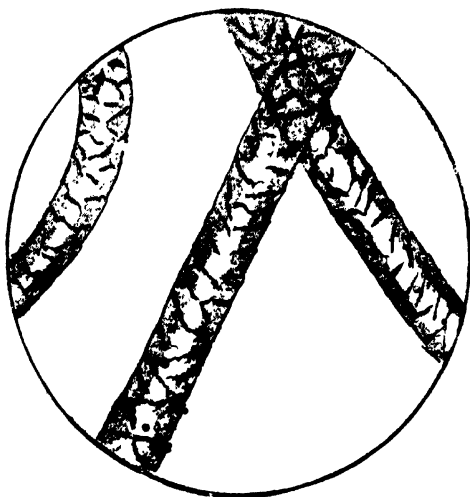


FIG. 14 shows the microscopic appearance of the wool fibre after being over-steamed, showing the scales of the fibre lying closer to the stem (compare this with Fig. 1, chap. i.).

Fig. 16 (A) represents the fibre steamed with an oxalic acid mordant, showing the scales slightly opened, while (B) is the wool fibre over-heated, showing how the characteristic appearance of the fibre is destroyed, and its internal fibrous structure becomes apparent. In this specimen the fibre was completely tendered.

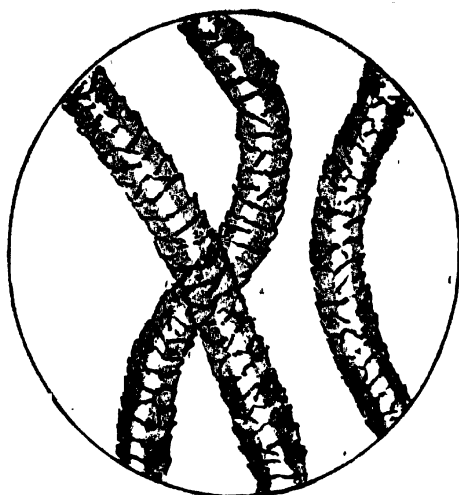


FIG. 15 shows the corroding effect of an excess of mordant (tin crystals) on the wool fibre. This fibre was rough and harsh to the feel.

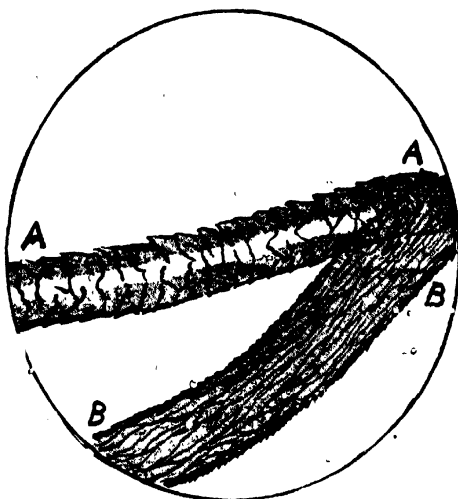


FIG. 16.—(A) shows wool fibre steamed with an acid mordant (oxalic), showing opening up of external scales. (B) represents wool fibre destroyed by overheating, revealing the fibrous nature of the interior of the wool fibre.

Colours composed of natural colouring matters, and having in their composition Acid Extract of Indigo, when combined with a reducing mordant like tin crystals, require to be aged after steaming, *i.e.*, left in a moist state for twelve hours in order to develop the reduced indigo, and bring the colours back to their original hue. With the aniline colours, where no reducing agent is employed, this ageing process is unnecessary, and the steamed yarns may be washed immediately after they have become cool.

CHAPTER XV

WASHING OF THE PRINTED AND STEAMED YARNS—HYDRO EXTRACTING.

Washing of the Printed Yarn.—The printed yarns, after being steamed, are hung to cool on a series of wooden pegs; and, if left overnight, it is desirable to cover them with a damp sheet to keep them moist, and prevent the colour paste from hardening on the fibre. Where aniline colours are solely used, the printed hanks may be washed immediately they are cool; but if the vegetable colouring matters are employed in conjunction with a tin mordant like tin crystals, or any other reducing mordant, the yarns require ageing, *i.e.*, left twenty-four hours in the moist state to enable the oxygen of the air to oxidise and develop any reduced colouring matters, such as acid indigo extract. After steaming there still adheres to the yarn the gum and flour paste which acted as the carrying medium for the dyes, and also a quantity of the unfixed and superfluous dyestuffs. These have to be removed with a careful washing in cold water. Several different methods of washing the printed hanks are employed. Some manufacturers prefer the ordinary style, similar to a scouring machine, where the yarns, partly submerged in a trough of water, are made to run over revolving reels or racers. By another method the water is made to dash down upon the outstretched and slowly-revolving hanks, and the force of the water playing on the yarn effectually cleanses it.

A simple and equally effective method consists in imitating mechanically the action of ordinary hand washing by swishing the hanks to and fro in a trough of water. This is performed by a simply constructed apparatus, having a long arm or pole, provided with a hook, on which the yarns are hung. This arm, being connected with an eccentric rod, is set in a rapid swinging motion over the water trough, and the hanks receive a brisk dashing to and fro through the water which thoroughly cleanses them. The position of the hanks has to be changed twice or thrice during each operation, to ensure every part of the yarn receiving the same amount of washing. The dirty water is run off into reservoirs to undergo a subsequent chemical treatment in order to purify it before being allowed to run into the neighbouring stream, as the question of river pollution, to dyers and carpet manufacturers, has now become one of serious importance.

A different method of washing hanks is employed in many of the works in Germany. The hanks of yarn are suspended upon rows of reels made of porcelain. These reels are made to rotate rapidly backwards and forwards, and while doing so the hanks are thoroughly washed by jets of water forced through them. These jets of water play upon the outside and the inside of the hank, and thus a thorough cleansing is ensured. Sometimes the porcelain reels are themselves perforated, through which the water is forced into the revolving hank.

An excellent form of yarn-washing machine is that made by Duncan Stewart of Glasgow. It consists of a U-shaped trough made either of wood or iron, which contains the water. A series of square copper reels, extending the full width of the trough, carry the hanks of yarn, the reels being placed about six inches above the water. These reels have two motions, one of revolution and, at the same time, one of intermittent motion, from the one end of the machine to the

other round U bend. This intermittent motion is given by a crank which causes each reel to move backwards and forwards about six inches; but the same time a continuous movement of the chain which carries the reels is superposed on this intermittent motion, with the result that the hanks which are put on the reels at one end are gradually carried along and removed at the other end. It is so arranged that the one man can both put on the hanks to wash and take off the washed ones. The various motions to which the hanks are subjected cleanse them most effectually.

Hydro extracting.—The yarns after washing are either wrung, squeezed, or hydro extracted, whereby the excess of

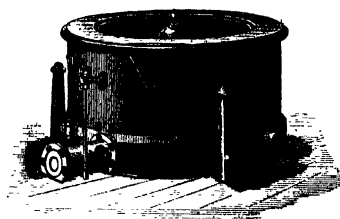


Fig. 17. Hydro extractor for yarns (Broadbent).

water is removed. The general form of hydro extractor for yarns is seen in our illustration (Fig. 17) (Broadbent & Sons). It consists of a perforated basket made of galvanised steel or copper, which revolves at the high speed of about 900 revolutions per minute. The water is thrown by centrifugal force towards the sides of the perforated cage, and escapes through the holes into a pipe at the bottom. If the cage be not properly balanced with the wet yarn, it has a tendency, when revolving, to oscillate or "wobble," which causes a strain and unnecessary vibration injurious to the machine. Care requires to be exercised in filling the basket to balance the weight, as much as possible. This can be learned after

a little experience. From experiment it seems that of the three methods just mentioned, *i.e.*, wringing, squeezing and extracting, the latter is the most effective in removing the excess of water. Thus, in fifteen minutes by the

<i>Wringer</i>	method	34	per cent.	of water is removed.
<i>Squeezer</i>	"	64	"	"
<i>Hydro extractor</i>	"	78	"	"

After the yarn is hydro extracted it is conveyed to the drying chamber, which is heated by means of a series of steam pipes running along the floor. The yarn is suspended upon poles until perfectly dry, after which it passes into the hands of the winder, setter, and finally to the weaver, where all the coloured threads, collected together in their own proper position, constitute the surface of the tapestry carpet.

These further stages in the process of manufacture lie beyond the scope of this little manual.

CHAPTER XVI.

ANILINE COLOURS SUITABLE FOR YARN PRINTING.

As many of the aniline colours prove highly suitable to the wool *dyer*, and yet are of little service to the printer of yarns, a selection of a few good wool printing colours may be of service. Unfortunately the wool *printer* cannot take advantage of the large class of dyes, so useful to the *dyer*, known as the adjective colouring matters, or those which require the assistance of a mordant to develop their colour powers. Among this group may be mentioned the Alizarines, Anthracene Browns, Yellows and Blues, Galloflavine, Gambines, Gallein, Erioxine, and others.

The fixing of the aniline colours on wool by steaming is based on the same principle as that of dyeing in the dye bath. As a rule, the acid dyestuffs are preferred to basic or neutral colours for yarn printing, as they are considered to work more evenly and give better results. Colours of a fugitive nature have always to be discarded. All the *Benzidine* dyestuffs, or the *Diamines* (cotton colours) give excellent results when printed on wool, their shades being level and fast, but their much higher price excludes them from a more general use.

The following may be taken as examples of good wool printing colours. The writer, however, is fully aware that many other excellent colours have been omitted, but space will not allow us to extend the list further:—

1. Red and Orange Colours.

Magenta (all kinds).
 Roccéllines.
 Fast Red.
 Azo Scarlets (all kinds).
 Wool, Victoria, Palatine, Croceine
 Scarlets.
 Eosines, such as Rhodamine Phlox-
 ine, Rosebongal, etc.
 Azo Oranges (all kinds).
 Azo Carmines.
 Azo Rubine.
 Brilliant Cochineal.
 Lanafuchine.
 Sorbine Red, etc.

2. Browns.

Bismarck Brown.
 Vesuvine.
 Acid Brown.
 Leather Brown, etc.

3. Yellows.

Auramine.
 Naphthol Yellows.
 Chrysoidine.
 Quinoline.
 Victoria Yellow.
 Uranine.
 Tartrazine.
 Fast and Acid Yellows, etc.

4. Greens.

Acid Greens.
 Brilliant Greens.
 Diamond "
 Victoria "

4. Green (cont.).

Malachite Greens.
 China "
 Wool "
 Light " etc.

5. Blues.

Victoria Blue.
 Night "
 Navy "
 Patent "
 Alkaline "
 Cyanine "
 Cyanole "
 Solid "
 Wool "
 Lanacyl " etc.

6. Violets.

Methyl Violets.
 Crystal "
 Acid "
 Azoacid "
 Formyl "
 Lanacyl " etc.

7. Greys and Blacks.

Aniline Grey.
 Methylene Grey.
 Fast "
 French "
 Indulines.
 Brilliant Black.
 Naphthol Blacks.
 Naphtylamine Black.
 Jet Black, etc.

CHAPTER XVII.

GLOSSARY OF DRUGS AND DYE WARES EMPLOYED IN WOOL YARN PRINTING.

THE term "mordant" is derived from the French *mordre* (to bite or corrode) (also in Latin *mordeo*, I bite) because the early French dyers concluded that the metallic salt, or mordant, fixed the colours on the fibre by reason of its biting or corroding action. To a certain extent, perhaps, this early idea of the use of a mordant is correct; but in the majority of cases the mordants enter into chemical combination with the colouring matters themselves. That mordants have indeed corrosive action on the fibre is readily seen in the illustration of the wool fibre steamed with an excess of tin crystals (see chap. xiv.). The following is a list of a few of the more important drugs, etc.:—

Acetate of Iron, Black Liquor, Pyrolignite of Iron, Iron Liquor, etc.—This, as a mordant for carpet yarn printing, has now a limited use. Before the introduction of the anilines it was largely employed for "saddening" and producing soft tertiary shades of olives, greys, russets or blacks with the vegetable colours containing tannin, like fustic, quercitron bark, sumac, cutch, etc. Except in a few special cases it is now seldom used in tapestry carpet colours.

Acetic Acid.— $C_2H_3O(OH)$ *Vinegar or Wood Acid.* This is occasionally used as a mordant for obtaining level and solid shades of colour where there is any tendency to unevenness. Many of the aniline colour stuffs, especially those of basic

nature, work more level and produce more satisfactory results after the addition of acetic acid. It also proves a useful solvent for many of the aniline dyes which are not so easily soluble in water. Where calcareous water is used for dyeing or colour dissolving, the hardness may be corrected by the addition of a little of this acid; about 1 part in 1000 of water. This is of importance, as many of the coal tar colours when dissolved with hard waters deposit tarry insoluble matters. Common commercial vinegar usually contains from 20 to 40 per cent. pure acetic acid $C_2H_3O(OH)$.

The specific gravity or degree Twaddle of vinegar is no guarantee whatever as to its true strength. To test the real strength and purity of the sample, a formal chemical analysis must be gone through. A common adulteration in commercial vinegars is the mineral acids sulphuric or hydrochloric. They give to the sample the appearance of greater strength by its increased acidity. The presence of these acids may be detected in the usual way. Treat a small portion of the sample with pure hydrochloric acid and barium chloride solution, when a white, heavy precipitate indicates sulphuric acid. To a fresh portion add a few drops pure nitric acid and nitrate of silver solution ($AgNO_3$) when a white, curdy precipitate shows the presence of hydrochloric acid (HCl). In some commercial vinegars, acetate of lead may be present in small quantity. The presence of this impurity indicates the absence of sulphuric acid. Vinegars containing lead impurities leave a residue on evaporation and show a white precipitate of sulphate of lead on adding to the sample a few drops H_2SO_4 .

Alkali, or Soda Ash, contains when pure 99 per cent. carbonate of soda, or 58 per cent. sodium oxide Na_2O . Its various strengths, chiefly 52°, 56° or 58°, represent the percentage sodium oxide (see Scouring Materials, chap. iii.).

Alum.—The alums are the crystallised double salts of sulphate of alumina and potash, soda or ammonia. Potash alum contains 10 per cent. alumina (Al_2O_3). Ammonia alum contains 11 per cent. alumina. The alum salts are of great importance to the carpet yarn printer. For their analysis and impurities see Alum, chap. viii.

Aluminium Sulphate, Patent Alums, Concentrated Alum, Sulphate of Alumina, is the normal salt $\text{Al}_2(\text{SO}_4)_3 + 18\text{H}_2\text{O}$, and is now largely used in place of the alums. It contains from 15 to 17 or 18 per cent. alumina (Al_2O_3). For its analysis and properties see end of chap. viii.

Ammonia, NH_3 .—This gas dissolved in water, forming the ammonia liquor of commerce, is a useful addition to the scouring bath. For table of specific gravity of ammonia liquor see Appendix.

Carbonate of Soda.—(Na_2CO_3), see Alkali; and also Carbonate of Soda, chap. iii.

Chlorate of Potash (KClO_3).—This powerful oxidising agent is sometimes added to colour pastes to give a sharp clean-cut outline in printing. When dissolved in paste at the rate of one ounce per gallon, with the addition of a little sulphuric acid, it makes a useful "discharge" for certain colours. This discharge may be used to edge strong shades which have a tendency to run, or what is technically called "bleed," on the yarn during the steaming. It plays the part of an oxidiser, decolourising any streaks of colour which might otherwise mar the sharpness of the printed outline.

Chromium Salts.—Although the chromium mordants are of great value to dyers, they are little used in the printing of tapestry yarns. Bichromate of potash ($\text{K}_2\text{Cr}_2\text{O}_7$) finds a limited use in conjunction with the yellow dyewoods like fustic, for producing pleasing old gold shades and buffs, or for giving rich browns with cutch. The large variety of beautiful shades obtained in dyeing with adjective colouring matters

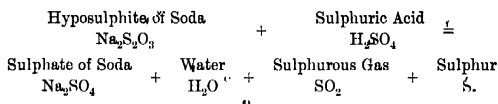
and a chrome mordant, are not obtainable in carpet printing. The colours produced are poor and unsatisfactory.

"*Crematine*." See tartaric acid substitutes.

Glauber's Salts, or sulphate of soda. ($\text{Na}_2\text{SO}_4 + 10\text{H}_2\text{O}$).—This salt may be used with advantage combined with an acid such as lactic, tartaric, or sulphuric. It helps to make the colours dye more uniformly on the yarn; preventing unevenness or the appearance of blotches, so unpleasant to see on the "grounds" of carpet patterns. In the steaming of printed yarns it seems to play the same part as in dyeing, *i.e.*, that of a levelling agent.

Hyposulphite of Soda (Antichlor.) ($\text{Na}_2\text{S}_2\text{O}_3 + 5\text{H}_2\text{O}$).—This salt is sometimes used in printing with the various basic aniline greens derived from dimethyl and diethyl aniline, such as Methyl, Malachite, Victoria, Benzoyl, Brilliant Greens, etc., also with the basic yellow colouring matter Auramine—a derivative of tetramethyldiamidobenzophenon. With these colours a sulphur mordant is of advantage to fix them to the yarn, and prevent their "bleeding" or forming a blurred outline. Greens of this class have a great tendency to "run" after being printed on the yarn, thus staining the white yarn next them. Amorphous sulphur, when precipitated on the wool fibre, acts as a mordant to colours of this nature; and to several others, which show little affinity for wool. Along with the hyposulphite of soda, a mineral acid (sulphuric) is required to decompose the salt and precipitate the sulphur in a very fine state upon the yarn. Sulphurous gas, SO_2 , is liberated in the colour paste at the same time, the smell of which is plainly felt from the colour. The greens become partially decolourised in the colour paste, owing to the reducing or bleaching action of the sulphur dioxide, present in minute bubbles throughout the paste. Colours containing this mordant must not be allowed to remain in copper vessels, otherwise the sulphur becomes deposited as a black film of

copper sulphide upon the copper. The reaction which takes place is as follows :—



It is this sulphur precipitated upon the fibre of the wool which forms the mordant, and gives to the wool and the colours the necessary affinity.

Lactic Acid ($\text{C}_3\text{H}_5\text{O}_3$).—This acid (50 per cent. strength) is now an article of commerce, and is being introduced into the dyeing and textile printing industries. In dyeing it is used as a chromium assistant, and for tapestry yarn printing it shows some interesting properties as a mordant and levelling agent. In its results it closely resembles tartaric acid ($\text{C}_4\text{H}_6\text{O}_6$). Lactic acid by itself is too weak an acid to thoroughly develop the acid or sulpho-colours in printing; hence its acidity requires to be increased by the addition of a little sulphuric or oxalic acids. With the natural colouring matters it shows to best advantage, producing rich and full shades. Where a purely acid mordant is required, as when using acid magenta or acid extract of indigo (indigotin-disulphonic acid), it is of little service, a stronger acid being necessary to develop such colouring matters. In point of acidity 25 parts lactic acid (50 per cent.) equal :—

10 parts tartaric acid, or
6 „ sulphuric acid.

For an investigation into the behaviour of lactic acid as a yarn printing mordant, with an account of its action on the various colouring matters, the reader may consult chapter viii., (see acid mordants with azo colours).

Lime Juice.—This is a crude Citric Acid ($\text{C}_6\text{H}_8\text{O}_7 \cdot \text{H}_2\text{O}$) and may sometimes be employed as an acid mordant in place of

tartaric acid. For manufacturing purposes, it appears as a dark-coloured liquid containing generally from 25 to 35 per cent. real citric acid. Its behaviour with the various colouring matters in yarn printing is very similar to that of tartaric acid.

Nitrate of Iron.—This preparation, which is generally normal ferric sulphate $\text{Fe}(\text{SO}_4)_3$, is made by acting on ferrous sulphate (FeSO_4) with sulphuric and nitric acids. The nitric acid merely acts as an oxidising agent, converting the ferrous into the ferric sulphate; hence the common name "Nitrate of Iron" is purely a misnomer, and apt to prove misleading. The ferric sulphate of commerce is a deep brown liquid, varying greatly in specific gravity from 50° to 100° Tw. Like acetate of iron it has but a limited use now in the printing of carpet yarns. It may still be employed as a "saddening" agent, when combined with the dyewoods containing tannin, like fustic or quercitron bark, producing useful shades of olive, sage, russet, grey, or black. It must be remembered, however, that where such iron salts are used in colour pastes, alumina salts must be absent, as the presence of alumina greatly destroys the "saddening" or darkening effect of the iron. Since the introduction of the many aniline colours, iron mordants have not been so largely used.

Oxalic Acid ($\text{C}_2\text{H}_2\text{O}_4$).—This strong vegetable acid is used to a considerable extent as an acid mordant to give colour pastes the sufficient acidity to develop the colours on the yarn. It must be employed with some caution; as an excess of oxalic acid has a tendency to corrode and "tender" the wool fibre in the process of steaming, see Fig. 16, chap. xiv. It is specially useful for developing cochineal scarlets, pinks, and bringing up the red in any colours where cochineal is a constituent. It also gives a clearer yellow cast to Quercitron Bark Yellows and Orange made with tin

crystals. It is a stronger acid than tartaric by about $\frac{1}{3}$; 12 parts oxalic acid having the neutralising power of 16 parts tartaric. It is an unsuitable acid for clear fustic yellows or buffs, producing redder and poorer tones of colour.

Patent Alum.—See Aluminium Sulphate.

Pearl Ash.—See Carbonate of Potash (chap. iii.).

Scouring Compositions.—See chap. iii.

Soaps.—See chap. iii.

Sulphate of Soda.—See *Glauber's Salts*.

Sulphuric Acid, or *Vitriol* (H_2SO_4).—This acid is largely employed in carpet printing for giving the colour paste its necessary acidity. Many of the tartaric acid substitutes which are put on the market owe their useful qualities to this acid. Its effects are seen to much advantage in using the aniline "acid" colours—the sulphonic derivatives, like the azo and oxy-azo reds, orange, or scarlets. After the addition of Glauber's salts, or sulphate alumina, to a dilute solution of sulphuric acid, a cheap and useful mordanting liquid may be obtained. "For table of percentage and specific gravity, see Appendix."

Tartaric Acid ($\text{C}_4\text{H}_6\text{O}_6$).—This vegetable acid is a valuable mordant in the printing of wool. Its strong acid properties (5 of tartaric representing 3 of strong sulphuric acid), combined with a non-injurious effect on the fibre of the wool, and its powers of developing colours to the best advantage, especially the natural dyestuffs, render it an ideal acid mordant in carpet printing. Being high in price, it is always desirable to substitute, whenever possible, some cheaper acid; such as sulphuric or oxalic; but it is found difficult to replace it altogether with advantage, especially with the natural colour-stuffs. The best degree of acidity for tapestry carpet printing is about 1 oz. (avoir.) per gallon of colour paste, or nearly 6·3 grams per litre. Tartaric acid, in the pure state, forms large, well-defined crystals, readily soluble in water.

If received in the powdered condition it is often advisable to examine it for impurities like bisulphate of potash ($\text{KH}.\text{SO}_4$). This adulteration is readily detected by dissolving a small portion of the powder in water, adding a few drops pure hydrochloric acid and barium chloride, when a heavy white precipitate shows the presence of potassium bisulphate. Another simple method is to heat the tartaric acid strongly on platinum foil; if pure, the tartaric will completely burn away, but, if impure, a white ash will remain.

Tartaric Substitutes.—As tartaric acid for commercial purposes is rather expensive, many substitutes have appeared in the market under various names, namely, "crematine," tartar cake, essence of tartar, tartaric liquid, protartar spirits, tartar substitute, etc. These compounds generally consist of mixtures, in varying proportions, of sulphuric acid, oxalic, bisulphates of potash or soda, nitre or salt cake, bye-products in the manufacture of nitric or hydrochloric acids. "Essence of tartar," for example, is a solution of tartaric acid strengthened with sulphuric acid. The writer has examined many of these compounds or "substitutes"; in some of them a considerable quantity of iron was present, but none were found which could not be more economically prepared by the colour-mixers themselves.

Tin Crystals ($\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$).—This mordant is of much importance to the carpet colourist, as with it some of the most useful shades are obtained. It is used solely for the natural colouring matters, and in conjunction with cochineal, quercitron, acid extract of indigo, fustic and archil, a great variety of useful shades of reds, greens, olives, russets, clarets, etc., are obtainable. As a rule, such shades have a softness of tone which is often difficult to match perfectly with the aniline colours. A pure sample of tin crystal should be perfectly white and dry, and feel smooth when rubbed between the fingers. It dissolves in a small quantity

of water with a clear solution; but on further addition of water, turbidity ensues, owing to the precipitation of a basic oxy-chloride, $2\text{Sn}(\text{OH})\text{Cl} : \text{H}_2\text{O}$; but on adding a few drops HCl , the solution again becomes clear. If in this clear solution barium chloride gives a white precipitate, this shows the presence of adulteration, probably sulphates of zinc or magnesia. Pure tin crystals contain 52 per cent. metallic tin.

Tin Spirits.—Various preparations containing tin as a base have been used by the dyer and carpet colour mixer, under the names of oxy and double muriates of tin, scarlet, spirits, yellow and finishing spirits, etc.; but these have gradually disappeared from use since the introduction of the Coal Tar Colouring Matters.

Vinegar.—See Acetic Acid.

Vitriol.—See Sulphuric Acid.

APPENDIX.

SPECIFIC GRAVITY *versus* TWADDELL HYDROMETER.

THE specific gravity of a liquid is an important consideration for acids, alkalies, solutions of mordants, etc., and is generally expressed in degrees Twaddell. On this scale of hydrometer the specific gravity of water = 0, and it can readily be converted into the direct specific gravity by the following simple calculation. To convert degrees Twaddell into specific gravity multiply by 5, *considering the product as decimals*, and add to it 1.000.

Thus, for example, commercial oil of vitriol stands 168° Tw., which in specific gravity would be

$$\begin{array}{r}
 168^{\circ} \text{ Tw.} \\
 \underline{5} \\
 \hline
 \cdot 840 \\
 1.000 \\
 \hline
 1.840 \text{ direct specific gravity.}
 \end{array}$$

For liquids lighter than water, such as ammonia, light oils, etc., hydrometers are employed.

If, on the other hand, the strength of the liquid be expressed in direct specific gravity, and its corresponding degree in Twaddell is wanted, subtract 1.000 and divide the remainder by 5, thus:—

$$\begin{array}{r}
 \cdot 840 \text{ specific gravity.} \\
 \underline{1.000} \\
 5 \overline{) \cdot 840} \\
 \underline{168^{\circ} \text{ Twaddell;}}
 \end{array}$$

or, if the specific gravity of a sample of Muriatic Acid be 1.160, then—

$$\begin{array}{r}
 1.160 \\
 \underline{1.000} \\
 5 \overline{) \cdot 160} \\
 \underline{82^{\circ} \text{ Twaddell.}}
 \end{array}$$

COMPARISON OF THERMOMETER SCALES.

For indicating the degrees of heat the ordinary Fahrenheit scale is most used in this country, although the simpler and more scientific scale is the Centigrade, as used in France.

	Freezing Point.	Boiling Point.
In the Fahrenheit scale —	32°	212°
In the Centigrade scale =	0°	100°

Rule to convert Centigrade into Fahrenheit (if temperature be above freezing point of water, and no lower temperature is required in dyeing and colour printing): multiply by 9, divide product by 5 and add to quotient 32, thus:—

$$\begin{array}{r}
 100^{\circ} \text{ Cent.} - 212^{\circ} \text{ Fah.} \\
 9 \\
 \hline
 5 \overline{) 900} \\
 \underline{180} \\
 32 \\
 \hline
 212^{\circ} \text{ Fah.}
 \end{array}$$

To convert degrees Fahrenheit into Centigrade above freezing point, subtract 32, multiply by 5 and divide the product by 9, thus:—

$$\begin{array}{r}
 162^{\circ} \text{ Fah.} = 72^{\circ} \text{ Cent.} \\
 32 \\
 \hline
 130 \\
 5 \\
 \hline
 9 \overline{) 650} \\
 \hline
 72^{\circ} \text{ Cent.}
 \end{array}$$

The following table gives an approximate comparison:—

Centigrade.	Fahrenheit	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.
100°	212°	78°	172°	56°	133°
98°	208°	76°	169°	54°	129°
96°	205°	74°	165°	52°	126°
94°	201°	72°	162°	50°	122°
92°	198°	70°	158°	48°	118°
90°	194°	68°	154°	46°	115°
88°	190°	66°	151°	44°	111°
86°	187°	64°	147°	42°	108°
84°	183°	62°	144°	40°	104°
82°	180°	60°	140°	38°	100°
80°	176°	58°	136°	36°	97°

Any lower temperature may be worked out according to above simple rules.

PERCENTAGE AND SPECIFIC GRAVITY OF AMMONIA LIQUOR AT 15° C.
(59° Fnh.).

Specific gravity.	Per Cent. Ammonia (NH ₃) according to Lunge.
0.882	34.95
0.890	34.75
0.900	28.33
0.908	25.65
0.916	23.00
0.924	20.49
0.930	18.64
0.940	15.68
0.950	12.74
0.960	9.91
0.980	4.80
0.994	1.37
1.000	0.00

PERCENTAGE AND SPECIFIC GRAVITY OF SULPHURIC ACID (H₂SO₄)
AT 60° Fnh. (Lunge).

Degrees Twaddell.	Per cent. H ₂ SO ₄ .	Degrees Twaddell.	Per cent. H ₂ SO ₄ .	Degrees Twaddell.	Per cent. H ₂ SO ₄ .
45°	30	90°	55	106°	62.5
50°	33	95°	57	112°	65
55°	36	98°	58	119°	68
60°	39	100°	59	127°	71
65°	42	101°	60	134°	74
70°	44	102°	60.5	142°	78
75°	47	103°	61	150°	81
80°	50	104°	61.5	159°	86
85°	52	105°	62	168°	100

YARN "COUNTS" OR Grist.

Worsted and Woollen Yarns.—In *worsted* yarns the counts indicate the number of hanks of 560 yards each to the pound weight. Thus a No. 1st thread yarn (*worsted*) has 35 yards to the ounce, avoirdupois, while a 14th thread yarn has $35 \times 14 = 490$ yards per ounce. If the thread be fourfold, viz., two by two, it will have 122½ yards per ounce, thus:—

$$\begin{array}{r} 4 \overline{) 490} \\ \underline{488} \\ 20 \end{array}$$

122½ yards per ounce 4 thread 14th.

and so on with the other qualities.

For *woollen* yarns a different method is adopted, and the standards vary in the various wool-spinning centres. In the west of England the counts represent the number of hanks of 320 yards each to every pound (avoirdupois), while in Yorkshire they go by the number of yards per dram, and in Dewsbury by the number of yards per ounce.

Cotton Yarn.—The counts of a cotton yarn is expressed by the number of hanks of 840 yards each which go to make a pound weight. Thus a No. 1^a cotton thread has 840 yards to the pound, or $52\frac{1}{2}$ yards per ounce. A 60^a one-thread cotton is a yarn which takes 60 hanks, each 840 yards, to make a pound weight. If the thread be, say, a 6 ply, No. 12^a, to get the number of yards per ounce multiply $52\frac{1}{2} \times 12 = 630$, divide by 6 = 105 yards per ounce of 12^a 6 ply cotton thread.

120 yards	=	1 skein.
7 skeins	=	1 hank.
18 hanks	=	1 spindle.

Linen.—The count of a linen yarn is indicated by the number of *leas* to the pound. A lea = 300 yards.

Jute.—The count of a jute yarn is the same as for linen.

Silk.—For spun silks the counts are the same as for cotton.

METRICAL MEASURE OF LENGTH.

The *metre* is the ten-millionth part of a line (*approx.*) drawn from the Pole to the Equator, and is taken as the unit of length.

1 millimetre	= $\frac{1}{1000}$ th of a metre	=	0.089 inches.
1 centimetre	= $\frac{1}{100}$ th " "	=	0.393 "
1 decimetre	= $\frac{1}{10}$ th " "	=	3.937 "
1 metre	= as above	=	3.280 feet.
1 decametre	= 10 metres	=	10.936 yards.
1 hectometre	= 100 "	=	109.363 " "
1 kilometre	= 1000 "	=	0.621 miles.

MEASURES OF WEIGHT.

The *gram*, which is taken as the unit of weight, is the weight of 1 cubic centimetre of pure water at 4° centigrade.

1 milligram	= $\frac{1}{1000}$ th of a gram	= 0.015 grains (troy).
1 centigram	= $\frac{1}{100}$ th " "	= 0.154 " "
1 decigram	= $\frac{1}{10}$ th " "	= 1.548 " "
1 gram	= as above	= 15.432 " "
1 decagram	= 10 grams	= 154.323 " "
1 hectogram	= 100 " "	= 3.529 oz. (avoir.).
1 kilogram	= 1000 " "	= 2.204 lb. " "

MEASURES OF CAPACITY.

The legal measure in this country is the imperial gallon; that is, a volume holding 10 pounds (avoirdupois) distilled water at 62° Fahrenheit. The gallon is divided into—

1 gallon	= 4 quarts.
1 quart	= 2 pints.
1 pint	= 4 gills.

In the metrical system the unit of capacity is the litre; that is, the volume of 1 cubic decimetre or 1000 cubic centimetres.

1 litre	= 1.760 pints.
1 decalitre = 10 litres	= 2.200 gallons.
1 hectolitre = 100 "	= 22.009 " "
1 kilolitre = 1000 "	= 220.096 " "
1 litre	= $1\frac{1}{4}$ pints (approximately).
100 "	= 22 gallons.

CONVERSION OF LITRES INTO GALLONS AND PINTS (*approximate*).

Litres.	Gallons.	Pints.	Gills.
1	—	1	3
2	—	3	2
3	—	5	1
4	—	7	—
5	—	8	3
6	1	2	2
7	1	4	1
8	1	6	—
9	1	7	3
10	2	1	2
11	2	3	$1\frac{1}{2}$
12	2	5	$0\frac{1}{2}$
13	2	6	$3\frac{1}{2}$
14	3	0	$2\frac{1}{2}$
15	3	2	$1\frac{1}{2}$
16	3	4	$0\frac{1}{2}$
17	3	5	$3\frac{1}{2}$

Litres.		Gallons.	Pints.	Gills.
18	=	8	7	2½
19	=	4	1	1½
20	=	4	3	0½
21	=	4	4	3½
22	=	4	6	2½
23	=	5	0	2
24	=	5	2	1
25	=	5	4	—
50	=	11	0	—
75	=	16	4	—
100	=	22	0	—

One gallon of water weighs 10 lb. (avoirdupois).

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